SCIENCE TEACHER'S WORLD

Teacher's edition of Science World • November 25, 1958

Putting thought behind science tests

"Give me control of the science tests of the nation," an outstanding scientist has said, "and I can change the course of science education in the United States."

Tests are indeed a strong weapon in the hands of the intelligent science teacher — a weapon that can be used to determine the degree to which science goals are achieved. Students are certainly test-conscious, as we know. Much of their studying is focused toward the passing of tests. And teachers themselves have a natural tendency to key instruction to tests.

Since tests play such an important role in shaping science education, we teachers must keep in the forefront of our thinking the reasons for giving tests. With these reasons constantly kept in mind, we can fashion better tests and exercise more control over the end result — the level of science education.

Tests, of course, even when given to "get a mark," are a means of evaluating the student. Good testing can be a large part of the evaluation process. Some teachers, in fact, prefer the term "evaluation," with its many attributes, to the colder term "testing."

What do we want to know?

But what are we to evaluate by our testing? Obviously, the old standard of evaluating students on the basis of their factual information is still adhered to in large degree. The variations of this information-by-recall type of testing will be discussed later. Unfortunately, most tests given to junior and senior high school students tend to fall largely in the information-recall classification. It is perhaps more important to evaluate a student's grasp of certain scientific procedures of an intellectual type. The evaluation of laboratory skills is also well worth while, as is testing for the understanding of principles and concepts. This last can be done by posing a new situation that does not repeat the exact framework of the textbook or the way the principles were learned in class.

One of the most useful purposes to which a test can be put is that of pre-testing — finding out in advance a student group's knowledge of and ability in a certain subject. This enables a teacher to pitch his work to a level commensurate with the students' knowledge and ability. Here, again, he must be selective to find what he is looking for. During the learning process it may become necessary to ascertain whether certain students are having difficulties and, if so, what these difficulties are. This can be done by the well-known diagnostic test. There are several types commercially available. But any good test can be a diagnostic instrument if the teacher analyzes results.

Tests can also be used to determine which of two or more methods of teaching is most suitable for particular students. The methods can be tried out on comparable classes, and the teacher can then test to find which produces the desired results. Another type of testing involves the prediction of future examination results. Many examinations of the Educational Testing Service and the College Entrance Examination Board fall into this category.

One cannot overemphasize how easy it is to fall into the trap of formulating a test that is purely factual recall. The danger of this test is that students tend to think that the test represents what the teacher wants them to learn.

When you build your own test, you may want to test for understanding of laws and theories and knowledge of technical terms. To test for student understanding of the application of laws and theories, you may want to give arithmetical problems or present verbal situations. You may want to test the generalizations studied in the course by applying them to specific natural phenomena. You want to test the relationship of certain facts to theories. And you may want to test the validity of some experiments as depicted in a problem set up in the examination.

Now let us consider the abilities you may want to evaluate. These could include: the ability to interpret tables, graphs, and the like; the ability to apply the methods of science to a given problem-situation; the ability to analyze an experiment critically; the ability to test a whole situation whose solution requires the application of several theories or principles; the ability to carry out the solution of certain equations and other operations and perhaps to use principles and theories in abstract situations.

It's possible that you may want to test attitudes. This is rather difficult with tests of your own making. Commercial tests, of course, are available for this purpose.

What will this test tell?

After you have decided what you want to evaluate, you have to consider whether the test will really give you the evaluation you want. Will the test be valid? Will it measure what it is supposed to measure? And is it reliable? Reliability is a statistical matter. You want to know how consistent the students' scores are as compared to those in similar tests. You also want to know how close the score would be if the test were given months later without preparation. Standardized tests generally have greater validity and reliability.

At one time the only type of test used was the well-known essay type.

This is often called a subjective test, in contrast to the many types of short-answer, or objective, tests. There are certain advantages to the essay type of question. A student is required to follow through an idea rather completely. His answer gives the teacher a better idea of his total development in a certain topic. But marking this type of examination can impose a staggering burden on a teacher with a full teaching load. And the essay-type question requires much more class time to answer.

One way around these problems is to include only one or two essay-type questions in a test and fill the rest of it with objective questions. In writing a question that requires an essay-type answer, the wording must be precise so that it does not lead the student astray. If you use this test you may want to organize your scoring to allow definite point values for the mechanics, organization, reasoning, and content. Another method is to fix definite point values for certain ideas that the students are expected to have mastered. A one-hour essay examination given to 100 students, if scored conscientiously, should take about thirty hours or more to mark. This is obviously quite a burden for a busy teacher.

One side issue to be considered is that the reading skill of particular classes must be taken into consideration.

Now let us take a look at the various types of short-answer, or objective, tests. In the notorious true-false test, the wording of statements must be so precise that each is true or false without the shadow of a doubt. One newer popular technique is to require the correct answer for each statement that a student marks false. This extends the true-false test into a modified short-form essay test. As such, it can be very useful for diagnostic testing.

The guessing factor in the true-false test varies with the number of questions, according to the following table:

No. of items	Chances of guessing at least 70%
10	1 in 6
25	1 in 50
50	1 in 350
100	1 in 10,000
200	1 in 1,000,000

It is obvious from this that short true-false tests should not be used.

The second most popular type of teacher-made test is the multiple-choice test. In this, there should never be fewer than four choices, and five is preferred. The guessing factor is of less importance than in the true-false test. With ten test items, the possibility of guessing 70 per cent correctly is only one chance in a thousand; with twenty-five items, it is one in a million. Thus, a twenty-five-item multiple-choice test reduces the chances of correct guessing to the same degree as a 200-item true-false test. Naturally, questions should be worded so that the correct answer does not stick out like a sore thumb. One answer should be the most completely correct. It is important to see that the wording of one question does not provide answers for another question.

The next most popular form of teacher-controlled test is the completion test. The problem here is that it is very difficult to construct a question to which one or two words are the only possible answers. Such a test cannot be marked mechanically. The teacher must accept correct alternative answers.

Matching tests provide one of the fastest types of testing, since only a letter or number need be written as an answer. There should be more possible answers to choose from than there are questions. Make certain that two answers do not fit one question in the matching column. The matching test does not fit all situations. It fits only situations where there are many important related facts and concepts.

Another type of short-answer test that has many advantages begins with a fairly long paragraph depicting a scientific problem situation, an experiment, observations, or the like. Below, there are multiple-choice questions to test the understanding of the ideas presented in the paragraph.

Many publishers sell tests for school use. The Educational Testing Service offers the newly developed STEP tests in science for use at different grade levels in junior and senior high school. These tests have been very carefully standardized, and national norms exist. There is also the well-known Iowa test, "General Background in the Natural Sciences." World Book Company publishes the Read General Science Test, the Nelson Biology Test, the Anderson Chemistry Test, and the Dunning Physics Test. Review books in high school sciences contain back copies of the past Regents tests used in New York State. Science Research Associates offers science tests, as does the Psychological Corporation. Naturally, these commercial tests are not free. Sometimes free tests are available from a local or state education department. — ALEXANDER JOSEPH

GOLD KEY REQUESTS

Are you planning any kind of awards-recognition at the end of the first semester? If so, now is the time to enter your request for the gold keys inscribed with the word "Science" that SCIENCE WORLD offers its teacher subscribers. These keys and their accompanying certificates are available ON REQUEST only. They should be requested according to this scale:

Student orders	Keys
10-100	1
101-200	2
201-300	3

and so on, for as many copies as you have ordered.

The keys may be awarded at your discretion to whichever student you wish to encourage with special recognition. Teachers who request keys at the end of the first semester may also request them at the end of the second semester.

MEMO

To: Science teachers

Subject: Ways to use this issue of SCIENCE WORLD in the classroom

Birth of a 'wonder drug'

CHEMISTRY TOPIC: organic chemistry
BIOLOGY TOPICS: cortisone, arthritis, adrenal and pituitary glands
GENERAL SCIENCE TOPIC: "wonder drugs"

This article traces the complete history of the work in steroid chemistry that led first to cortisone and then to similar but more effective drugs.

The reader is given an idea of the painstaking work, the heartaches and failures, and the successes of scientists working in a new field of medical research. The article cuts a swath across the fields of chemistry and biology. It will answer for many students the puzzling question concerning the nature and the physiological action of one group of the so-called wonder drugs. In biology, the article can be tied in closely with the study of the adrenal glands and the pituitary gland.

Class discussion

1. What is a steroid?
2. For what diseases other than arthritis are steroids useful?
3. Why was it so difficult to make the first cortisone?
4. Why is cortisone not a cure?
5. What effect does cortisone have upon the cells surrounding an inflamed area?

Class activity

From a drugstore or a physician, obtain samples of steroid drugs for display.

In the stratosphere

PHYSICS TOPICS: stratosphere, kinetic theory of gases, cosmic rays, ionized gases
GENERAL SCIENCE TOPICS: the atmosphere, balloons, temperatures at levels above the earth

Here is a superb personal tale by the first man to penetrate the stratosphere. It will convey to the student Auguste Piccard's enthusiasm and his vital reasons for building the first stratospheric balloon. The student will follow this eminent physicist through the trials and tribulations of his venture high into the atmosphere. At the same time, the student will learn the scientific reasons for the flight and will observe that it was not a stunt but a serious search for scientific information to change or verify theories current during Piccard's early days.

Class discussion

1. What made Piccard undertake the first flight into the stratosphere?
2. What scientific information was Piccard searching for?
3. What problems were faced during the first stratospheric flight?
4. Why was it necessary to study cosmic rays at a high altitude?
5. How were Piccard and his assistant protected against the extremely low air pressure at the edge of the stratosphere?

Projects and experiments

1. Use a bell jar containing an aneroid barometer or an altimeter. With vaseline, seal the bottom of the bell jar against a sheet of glass. Attach a hand vacuum pump to the bell jar and, by pumping, lower the internal pressure to that approximating the stratosphere's.
2. Have students make a model of the first gondola that Piccard attached to his balloon.

On the light side

PHYSICS TOPICS: optics, persistence of vision
MATHEMATICS TOPICS: puzzles, computers
BIOLOGY TOPIC: variations
GENERAL SCIENCE TOPIC: meteors

This collection of short items

YOUNG SCIENTISTS

Teachers are urged to have their students submit write-ups of interesting projects or experiments they have done. If printed in SCIENCE WORLD, full credit will be given to the student, the school, and the teacher. In addition, the student will receive $15. Contributions should be addressed to Science Project Editor, Science World, 575 Madison Avenue, New York 22, N.Y. Students should be reminded that by submitting their ideas they can do a service to thousands of other students.

covers almost all of the junior and high school sciences. The items may be used to motivate lessons on the topics listed above. Some teachers find "On the Light Side" very useful for the closing minutes of the science period on Fridays.

Power from the tides

PHYSICS TOPICS: gravitational attraction, water pressure
GENERAL SCIENCE TOPICS: water power, tides
EARTH SCIENCE TOPICS: tides, moon and sun

This article reviews past and present projects for harnessing water power where tides are very high. It explains the astronomical causes for these tides. The illustrations show how tides are formed and how one tidal-power project would work. The physics teacher can use the article to review hydrostatics and gravitational attraction. In general science and earth science classes, the study of tides and water power may be motivated by the reading of the article.

Class discussion

1. Why is tidal power needed now?
2. What is the history of tidal-power development?
3. Where are the highest tides recorded?
4. How much power might be generated by tidal-power dams?
5. What causes tides?
6. Why isn't solar energy now used on a large scale?

Projects and experiments

1. Have students make a model of the Passamaquoddy project.
2. Ask students to make a chart of the tides along the coastline nearest to their homes.

Case of the silent howlers

BIOLOGY AND GENERAL SCIENCE TOPICS: yellow fever, mosquito vector diseases, public health

Part II of this article tells the fascinating detective story of the hunt for a new mosquito vector of yellow fever. This story is, in fact, far more interesting than many "whodunits." It provides a wonderful opportunity for students to see the international scope of medical activity and research in the prevention of the spread of diseases. Students will also get an insight into the dedication of the research doctors who slave in the jungle to save the lives of possible millions of their fellow men. In the study of a unit on diseases spread by mosquitoes, the general science and the biology teachers may find no motivational device that will hit home as well as this true adventure story. (See "Memo" in the November 11 issue to find how a number of topics in the biology syllabus can be related to the article.)

Class discussion

1. What is the difference between urban yellow fever and jungle yellow fever?
2. How does the experience of Dr. Boshell illustrate that scientists should be skeptical of accepted theories?
3. What was the mystery of jungle yellow fever and how was it solved?
4. How did the yellow-fever virus survive in the forest during the dry season?

Projects and experiments

1. Have students make models with modeling clay of the *Culex*, *Anopheles*, and *Aedes aegypti* mosquitoes.
2. Have students make a map of the world, showing areas where yellow fever is endemic.

How bats see by sound

BIOLOGY TOPICS: hearing, nervous system of bat
PHYSICS TOPICS: ultrasonics, reflections, sonar
GENERAL SCIENCE TOPICS: sound, navigation, hearing

Again we find an article that cuts across many disciplines. And students have the opportunity of seeing how zoologists set up their experiments to study the behavior of animals. Students may want to delve into echo navigation by experimenting with echoes of their own voices, if the terrain permits. The extremely lightweight echo-ranging system of the bat, as compared to man's complex sonar devices, can give the teacher and students food for thought.

Class discussions

1. How does a bat produce high-frequency vibrations?
2. How does a bat receive the vibrations?
3. What theory would explain why the outgoing signals don't interfere with the reception of the echoes?
4. How does a bat locate and catch insects?
5. What happens to bats whose ears are covered?
6. Why can we say that some bats have FM transmission and reception?
7. What happens to a bat's echo signal as the bat closes in on an insect?

Projects and experiments

1. If possible, capture a bat with a net and study it. (Since a bat's bite is frequently dangerous, handle with care and wear heavy gloves.) See if the bat will respond to a Galton whistle (ultrasonic dog whistle). Try different frequencies above the human hearing range.
2. Have students draw the sound-making apparatus and the specialized ear of a bat.

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VEMBER 25, 1958

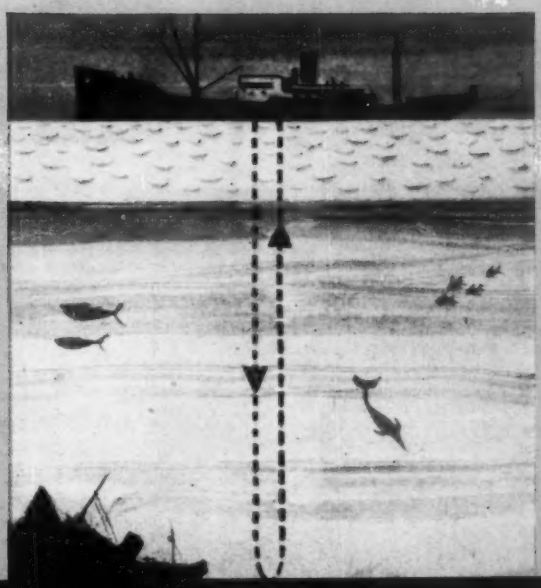
SCIENCE WORLD

E SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS

What do these have in common?

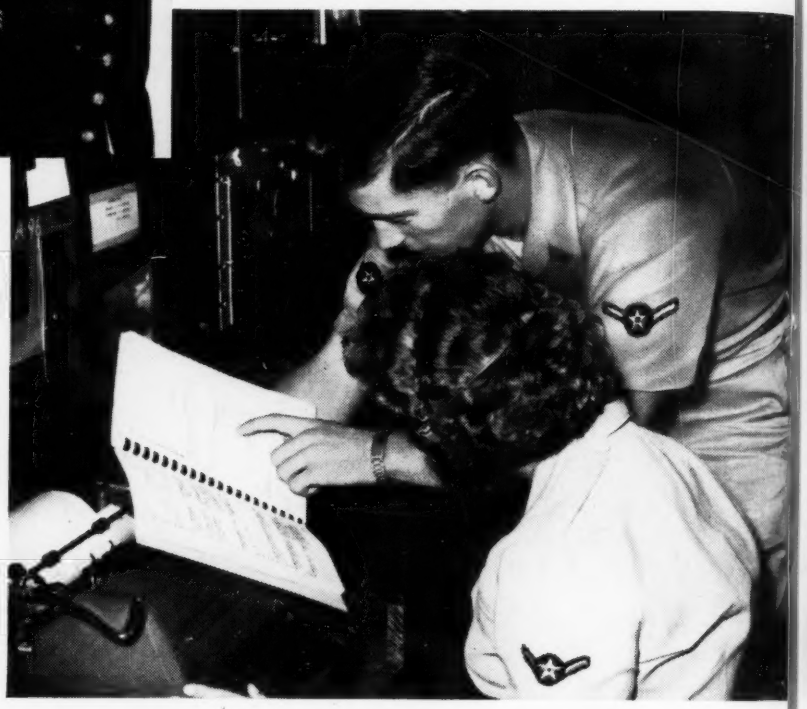
ee page 10)

Leonardo da Vinci's flying machine



Sonar: modern aid to navigation

JOIN THE MEN AND WOMEN OF THE U.S. AIR FORCE



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Coming in SW December 9

How dangerous to the United States is jungle yellow fever?

What conditions did explorer-physicist Auguste Piccard find in the stratosphere?

When did scientists discover that the atom was composed of still tinier sub-atomic particles? What tremendous scientific advance followed?

In what ways do studies of a cow's stomach help us?

For answers, see next issue of *SW*.

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Cover: Drawing by Peter Burchard from a model in the Arts and Sciences Department of International Business Machines Corporation. Ship and sonar, courtesy of Raytheon Manufacturing Company

When readers write (2)

An issue or so ago we had something to say about the kinds of letters we don't like to receive — because we cannot offer the help they request. So this time we'd like to mention the kind of mail we're delighted to find on our desk.

We look forward to receiving contributions to the "Young Scientists" pages — a description of the project you did last year or are working on this year. Here's a chance to share your ideas with other students — and to earn $15 if your project is published. We also like to receive questions for "Question Box" and coupons for materials listed in "Yours for the Asking."

Last, but not least, we just plain like to hear from you. We like to find out which articles you found most interesting and helpful, what subjects you'd like us to include in future issues. Your reactions are one of our most important guides in future planning.

BIRTH OF A 'WONDER DRUG'

By E. H. Harvey Jr.

The date was September 21, 1948. A 29-year-old woman lay in a hospital bed at the Mayo Clinic in Rochester, Minnesota. She was unable to move without excruciating pain; many of her joints were stiff and swollen. Over a span of four and a half years, she had been suffering from severe rheumatoid arthritis, and the disease had grown progressively worse.

That morning, a substance called cortisone — untested till then in arthritic patients — was injected. Three days later the woman walked out of the Mayo Clinic and downtown for an afternoon of shopping.

Cortisone, or "Cortone," as its developers, Merck & Co., Inc., called it, was immediately hailed as a "wonder drug." But, like all such drugs, cortisone had been produced by years of study, trial and error, and just plain luck. Dr. Lewis H. Sarett, who is literally "the man who made cortisone," will attest to that. He will also say that cortisone's dramatic debut in 1948 marked a turning point, not a finale, in the search for a true "wonder drug." But that is getting ahead of the story.

Cortisone is a hormone. It is secreted naturally by the human adrenals, two small glands adjacent to the kidney. Man-made cortisone is identical to natural cortisone.

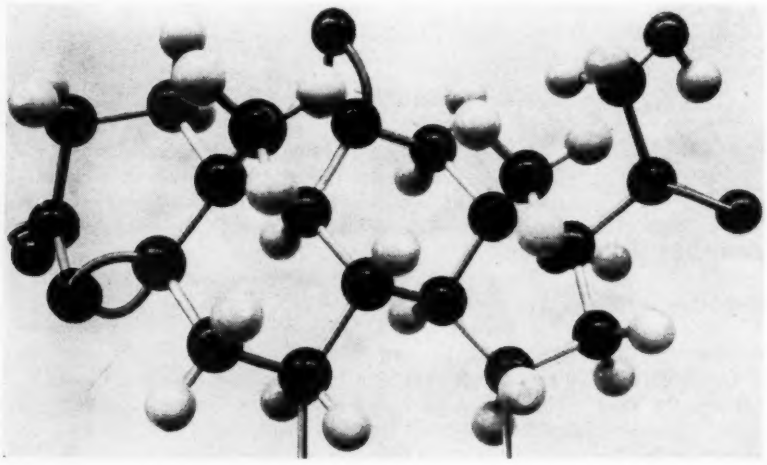
As far back as the early 1930's, a few pioneering scientists had begun to investigate the substances in the cortex, or "bark," of animal adrenal glands. One of those scientists was Dr. Edward C. Kendall, who in 1914 had isolated the key compound in another important gland, the thyroid. Working with beef adrenals, Dr. Kendall eventually succeeded in isolating four crystalline compounds from the adrenal cortex. These he labeled A, B, E, and F. Dr. Kendall suspected that any of these compounds might prove medically active. His particular choice was A. But making one small white tablet of pure compound required 1,000 pounds of beef adrenal glands. Clearly, this method could never yield enough Compound A to make the necessary lab and clinical tests. Dr. Kendall realized there was only one hope: finding a way to make these compounds by chemical synthesis — that is, by finding a chemical means of creating the compounds in the lab.

That is where matters stood until late in 1941. Then, just before the United States entered World War II, a disturbing rumor reached the U.S. Government. The Germans reputedly were buying up huge quantities of beef adrenal glands from Argentine slaughterhouses, extracting certain hormones, and feeding these hormones to their pilots. This enabled German pilots (so the rumor went) to fly and fight at unheard-of altitudes without special equipment.

The rumor eventually proved untrue. But it was enough to convince the U.S. Office of Scientific Research and Development that every possible effort should be made to determine the effects of various adrenal extracts on man. OSRD contacted several independent, private, and industrial research labs — among them Merck & Co. and the Mayo Clinic — and gave them the go-ahead on a Government-financed crash program. Objective: synthesize adrenal extracts and find how they affect human beings.

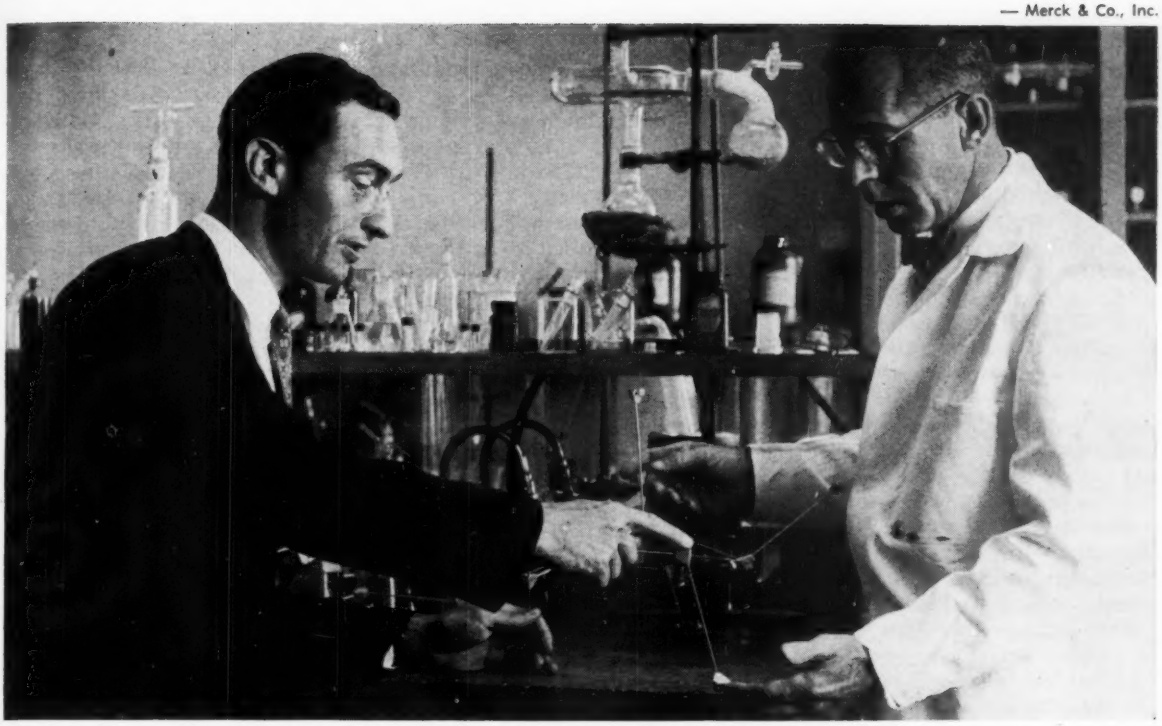
Under the leadership of Dr. Kendall and with help from scientists of the Merck Sharp & Dohme Research Laboratories, Compound A was the first adrenal hormone to be successfully synthesized. But it was a bitter disappointment. Compound A had little effect where it should have been most effective: on patients whose adrenal glands had been destroyed by Addison's disease.

At this point Dr. Sarett came into the picture. When Merck had hired him in 1942, Dr. Sarett was 24 years old and had just received his Ph.D from Princeton. Merck gave him the assignment of trying to produce



MODEL OF CORTISONE MOLECULE shows precise arrangement of its 21 carbon atoms, 28 hydrogen atoms, and 5 oxygen atoms. Cortisone, a hormone produced by glands, was first made in the laboratory by Dr. Lewis H. Sarett. At the time, the cortisone molecule was the most complex molecule ever to be made synthetically.

— Merck & Co., Inc.



MAN WHO MADE CORTISONE, Dr. Sarett (*left*), and Dr. Glen Arth headed scientific team that produced an even more potent drug.

Compound E by chemical synthesis. Dr. Sarett was well qualified for the assignment. As a stereochemist, his specialty was the inside of an organic molecule, the spatial relations of its atoms. He was interested in the infinitesimal distances between atoms in an organic molecule: how these distances affected the properties of the molecule and what would happen if the spatial arrangement of atoms were changed. Dr. Sarett had another qualification. "All Dr. Kendall's compounds," he explains, "were of the steroid class of organic molecules. In my graduate work at Princeton I had specialized in the study of steroids."

(A steroid is any of a class of compounds containing the carbon ring system of the sterols. And a sterol is any of a class of solid alcohols, such as cholesterol, which are widely distributed in plants and animals.)

"The obvious thing to do back in 1942," Dr. Sarett recalls, "was to find a substance that, like Compound E, had a steroid structure. We would then take away the atoms we didn't want and replace them with the atoms we did want. This method is known as 'partial synthesis,' because you start with part of what you eventually want to have. In 'total synthesis' you don't have this head start. You begin with nothing but the raw atomic materials."

Two years after he began work, Dr. Sarett announced the successful synthesis of Compound E. "It's not modesty," says Dr. Sarett, "that makes me say that I couldn't have completed the synthesis without the help of previous research done by Dr. Kendall and many other scientists in the U.S. and abroad." Nevertheless, Dr. Sarett's synthesis of Compound E was, at the time, the most difficult synthesis ever performed.

Though a brilliant scientific feat, Dr. Sarett's method of synthesis was also terribly complicated, time-consuming, and inefficient. More than thirty separate, delicate, and carefully timed chemical reactions were required to produce a very small amount of Compound E. Therefore, many more months elapsed before Merck chemists could make the refinements in Dr. Sarett's process that were needed to produce workable amounts of Compound E. Finally, however, enough was produced. Tests were conducted with animals, then with human patients. Finally, the few remaining precious grams were sent to Dr. Philip S. Hench at the Mayo Clinic. He had long had a hunch that adrenal hormones might help patients with rheumatoid arthritis. His hunch was right. The results, as previously noted, were startling. Compound E had become cortisone. Drs. Hench and Kendall won the Nobel Prize for their efforts.

However, it became apparent that the "miracle drug" was both better and worse than scientists had hoped. It was less satisfactory for two reasons. In prolonged treatments, cortisone could produce annoying, and sometime dangerous, side effects; and it did not attack the *cause* of rheumatoid arthritis. Instead, it protected nearby cells and tissues against what is thought to be the causative irritant. But that was exactly what made cortisone promising. If it protected cells against irritation and inflammation, then, scientists reasoned, it

might be valuable in treating an astonishing range of human diseases.

Not all these early hopes proved valid. But cortisone's dramatic effect on rheumatoid arthritis gave medical scientists a hint as to what diseases would be most likely to respond to cortisone treatment. Doctors had known for some years that jaundice or pregnancy improved the condition of rheumatoid arthritics. They didn't know *why*, but it happened. Therefore, medical scientists asked, wouldn't it be a good idea to make a list of all the diseases that jaundice and pregnancy seemed to relieve and try cortisone on each of them?

This proved a productive line of reasoning. Through it, doctors found that cortisone was valuable in treating such seemingly unrelated diseases and afflictions as rheumatic fever, Still's disease, bronchial asthma, many allergies, and certain inflammatory eye diseases, to name but a few. In the process, medical scientists learned why so many diseases were relieved by jaundice and pregnancy. The liver, they found, breaks down the hormones secreted by the adrenal glands. This breakdown goes on at the same rate, even when the adrenal gland is deficient or diseased and unable to supply its usual quota of anti-inflammatory steroids to the body cells. But if the liver *also* becomes diseased (as in jaundice) or if the adrenals become more active (as in pregnancy), more of the adrenal hormones become available for the rest of the body.

But the most far-reaching benefit of early medical research with cortisone was a new insight into the nature of disease. Many diseases, it was discovered, were fatal or disabling *not* because of the germ or virus as such but because tissues, in reacting, became excessively irritated and inflamed. With this new knowledge, doctors could begin to use cortisone together with antibiotics in treating tissue-damaging diseases like tuberculosis.

By 1950, cortisone had brought about major advances in the treatment of many diseases and helped broaden medical knowledge about the very nature of disease. But the serious problem of side effects remained.

Consequently, pharmaceutical companies engaged in an all-out search for an improved cortisone. Late in 1950, a Merck research team produced Kendall's long-neglected Compound F by partial chemical synthesis, calling it hydrocortisone. Clinical tests showed hydrocortisone to be slightly more potent, milligram for milligram, than cortisone; and it produced fewer undesirable side effects. But pharmaceutical scientists believed they could do better.

During the early part of the search for an improved cortisone, Merck's Dr. Sarett had headed a group that was working on the production of cortisone by total synthesis. It was a job that took them four years to complete, and, as far as practical value was concerned, it had none. "By the time the total synthesis was completed in 1952," says Dr. Sarett, "there had been tremendous improvements in the original partial synthesis method. There was no question that cortisone could be produced more economically by partial synthesis. Our four years of work on total synthesis, therefore, had no commercial value. But I don't consider it wasted effort. We learned a great deal."

A new approach

Around the time Dr. Sarett's group achieved the total synthesis of cortisone, several steroid-research groups in the pharmaceutical industry were beginning to consider two intriguing theories. The first was that certain steroids might prove valuable as anesthetics. The second theory was far more sweeping and revolutionary. This was the suspicion that artificial hormones, chemically unlike any steroids found in the adrenal gland, might do a better job and produce fewer side effects than natural hormones.

E. R. Squibb & Sons was the first pharmaceutical company to prove that artificial hormones were a definite medical possibility. Squibb researchers succeeded in manipulating fluorine atoms into the steroid nucleus of hydrocortisone, Compound F. When tested, this new compound showed ten times the potency of hydrocortisone in protecting animal tissues against artificially induced inflammation. But its side effects were more pronounced than cortisone's.

Then, in 1955, Schering Corporation, Merck Sharp & Dohme, and others introduced Prednisone and Prednisolone. These were four to five times more potent than cortisone and had fewer side effects.

At Merck, meanwhile, Dr. Sarett and Dr. Glen Arth, a chemist who had worked with him on production of cortisone by total synthesis, were investigating the anesthetic possibilities of various non-adrenal steroids.

"We eventually found one steroid," Dr. Sarett says, "that proved a powerful anesthetic. Then we discovered we couldn't make it stable enough to market, without destroying its anesthetic effectiveness." That proved to be one of the most fortunate failures in pharmaceutical history.

Merck called a halt to research on steroid anesthetics, leaving Drs. Sarett and Arth with a whole new group of apparently worthless steroids on their hands. But were these steroids really worthless? They were no good as anti-inflammatory agents, but their unique chemistry interested the researchers. Using them as starting materials, they began to build up, one after another, a number of new compounds for routine tests with animals.

What followed was incredible. One of the compounds Drs. Sarett and Arth produced for testing showed about ten times the potency of hydrocortisone, with no determinable side effects. The potency of one of the next compounds turned out to be about thirty times greater. And it had fewer apparent side effects.

Merck Sharp & Dohme called the new steroid Decadron. Within weeks, more than a hundred Merck scientists, technicians, and other personnel were engaged in a crash program to produce Decadron in quantity.

Now Decadron is becoming available to doctors for the treatment of patients, and another chapter on steroid research has been written into medical history.

By D. S. Halacy Jr.

Power from the tides

As conventional sources of power become scarcer, steps are being taken to tap the endless energy of the sea's rise and fall

Twice a day, 100 billion tons of water rush in and out of Canada's Bay of Fundy. All over the world there are similar, though less dramatic, movements of water. These are the tides — the alternate rise and fall of the oceans. Locked in the tides are tremendous stores of energy. Plans are now being made to tap this energy to produce more than 100 billion kilowatt hours of electric power a year.

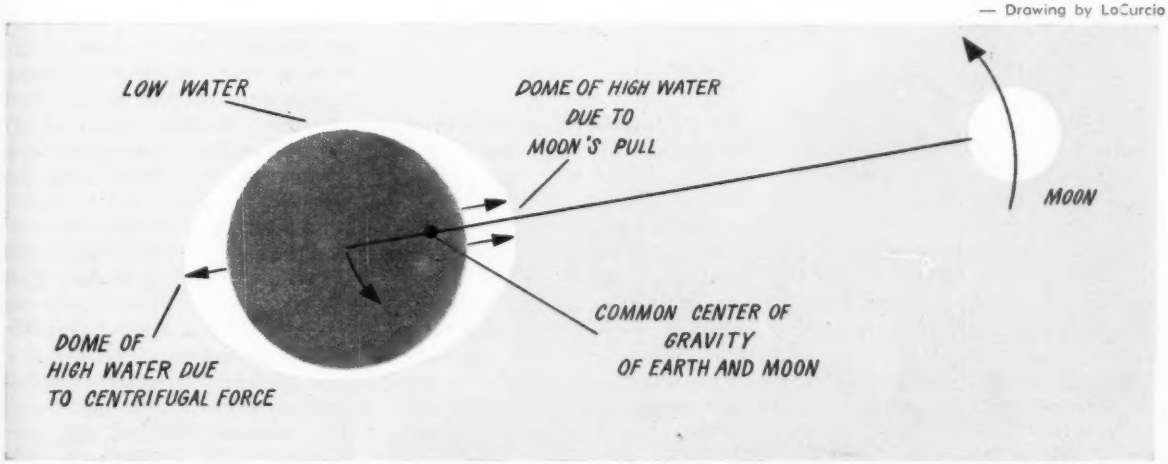
No far-fetched dream, tidal power plants are under construction today in France. The United States and Canada are also studying the possibility of harnessing the tides, particularly in the Bays of Passamaquoddy and Cobscook on the Maine-Canada border. There are good reasons for this growing interest in the tides.

For many centuries man has been using up what we might call "capital" energy. This is the legacy left him by the earth's development over millions of years. Capital energy is fine, as far as it goes, but it won't go much farther. A large share of our capital energy is in the form of the fossil fuels — coal, oil, and gas. These are so handy and cheap that during the last century alone we have used almost as much fuel as that consumed between the year of Christ's birth and 1850. And as the population keeps increasing, so will the rate of consumption. Therefore we must figure ways of using "income" energy — those sources of power that are eternal.

Solar energy offers the greatest potential. But the economical use of the sun's rays won't be possible until sometime in the future. So we must use secondary sources of energy for the present and immediate future. Wind power, for example, is being used to pump water and to develop small amounts of electricity. And hydroelectric plants at dams convert water power into electrical power, now providing about 1 per cent of the world's needs. Another kind of water power is that available from the tides.

Tides are caused by two factors: gravitational attraction and the ro-

— Drawing by LoCurcio


LOW WATER
DOME OF HIGH WATER DUE TO MOON'S PULL
MOON
COMMON CENTER OF GRAVITY OF EARTH AND MOON
DOME OF HIGH WATER DUE TO CENTRIFUGAL FORCE

PULL OF MOON'S GRAVITY creates high tide on side of earth facing moon. Another high tide is formed on opposite side. Reason: Both earth and moon revolve around a point within the earth — their common center of gravity. As the earth moves around this point, centrifugal force tends to throw water outward from the earth on the side opposite.

Newsweek — Magill

TIDAL POWER PROJECT may follow this plan: Dams and gates cut off Passamaquoddy and Cobscook Bays from Bay of Fundy. Water from high tide enters through gate (1) to high pool (2), drops through power plant (3) to pool (4), goes out (5).

tation of the earth. We know that all heavenly bodies attract each other with the force called gravitation. In theory, even the most distant stars tug at the earth (and vice versa). But only the moon and the sun are close enough to exert much pull. Their pull affects every particle of the earth, and especially water.

The moon has the greater effect. As a result of the moon's direct pull, a dome of high water forms on the side of the earth facing the moon. Surprisingly, another dome forms on the side of the earth opposite the moon (the drawing on page 7 explains why). In between the two domes, the water level is lowered. In this way, high and low tides are created.

The sun's attraction, though only about half that of the moon, also affects the tides. The sun's position in relation to the moon determines how high or low tides become. When the sun and the moon are in a line with the earth, their pulls are combined. We then have very high and very low tides. The high tides are called "spring" (in the sense of *jump*) tides. They come after full and new moons.

When the moon and the sun are pulling at an angle to each other, the sun's attraction partly cancels that of the moon. High tides are lower and low tides higher. These high tides are known as "neap" (*scanty*) tides. They occur after the moon is at its first and third quarters.

If the earth didn't rotate, the domes of high water wouldn't move. They would remain in the same locations on the earth. But the earth does turn beneath the domes. The tides move accordingly, bringing to an area a succession of high and low tides. As the earth rotates, the tidal movements cause considerable drag on the ocean floor. This drag is actually slowing down the speed of the earth's rotation. But there's no cause for alarm. The slowdown is at a rate of only about one second every thousand years.

If the earth were a perfectly smooth sphere, covered with water of equal depth, tides would be uniform and easily predictable. But this is not the case. There are depressions of all shapes and sizes. As a result, we have a complex variety of tides around the earth.

The usual tidal cycle (from high tide to high tide) occurs twice daily. This is easy to understand when we remember two points: (1) a dome of high water is formed not only on the side of the earth facing the moon, but also on the opposite side; and (2) the moon makes its apparent circuit of the earth in slightly more than a day. In the Atlantic Ocean, tides twice a day are normal. But in some places, such as Saint Michael in Alaska, there is only one cycle daily. There are even, in other parts of the world, complex cycles consisting of a single tide for several days, followed by two tides a day.

More surprising is the variation in the height of tides. Some localities measure tides in inches, while Canada's Bay of Fundy has a fantastic tide 50 feet high. Nantucket, not far from Fundy, has a tide of only 1.5 feet. Particularly puzzling are the tides of the Panama Canal. The Atlantic side of the canal measures tides of from 1 to 2 feet. The Pacific side, just forty miles away, records tides as high as 16 feet. These seeming paradoxes can

all be explained with the help of complicated mathematics.

(The so-called tidal wave, by the way, bears no relation to tides. It's caused by underwater earthquakes or by atmospheric disturbances.)

As water rises and falls with the tides, tidal currents are formed. Where there are twice-daily tides, a "flood current" flows shoreward for about six hours. Then an "ebb current" reverses this direction for the same length of time. The currents are the source of tidal energy.

Tidal energy should not be confused with wave power. Years ago, a scientist-prince, Albert of Monaco, tried unsuccessfully to harness the seemingly powerful slap of waves on the shore. Tidal power is more closely allied with that of a waterfall or a hydroelectric dam such as Hoover or Grand Coulee. But perhaps the best comparison would be with mill-wheel power.

The simplest way to produce tidal power would be to let the sea at high tide fill a basin. At low tide, the water draining from the basin could turn a mill wheel and operate a generator.

The first American to do anything about tidal power was an engineer named Dexter Cooper. He was fascinated by the 20-foot tides of Passamaquoddy Bay. After studying how these tides might be used to provide electrical power, he mentioned his idea to a friend, Franklin D. Roosevelt. FDR first advocated such a project in his 1920 vice-presidential campaign.

Later, as President, Roosevelt allocated funds for preliminary work on the tidal project. Studies revealed that a Passamaquoddy-Cobscook hydroelectric plant could produce three billion kilowatt hours of electricity a year. But the cost of the project would have been from 100 to 300 million dollars, and, in 1936, Congress refused further funds for the project.

Meanwhile, France and Germany were working on a similar idea. All three countries developed designs for generators that could be used effectively to harness the tides.

France is now constructing a tidal power plant on the Rance River, where there are 37-foot tides. A dam 2,300 feet long will create a tidal basin of about 85 square miles. Equipped with thirty-eight generators, the Rance River plant will furnish 800 million kilowatt hours of power a year. This may well meet most of the surrounding area's electrical needs.

The French hope to have ten generators in operation by 1960 and all thirty-eight by 1963. Far from being a costly experiment, this plant is being built to compete on a price basis with conventional power systems.

The Rance River plant is considered only a forerunner of a much larger tidal power system in France. Mont-Saint-Michel, known for its famous abbey, has phenomenal 40-foot tides that have drowned unwary travelers walking the sands of its huge tidal basin. With an area of 235 square miles, the Mont-Saint-Michel project would furnish an estimated 15 billion kilowatt hours yearly. That amount is equal to 30 per cent of the country's present power needs.

England also has a good tidal-power potential in its Severn Estuary. But Russia has the champion of all tidal basins. The Mezen Gulf is estimated to have a potential of 72 billion kilowatt hours a year. This gives Russia the prospect of someday developing more tidal electric power than the rest of the world combined.

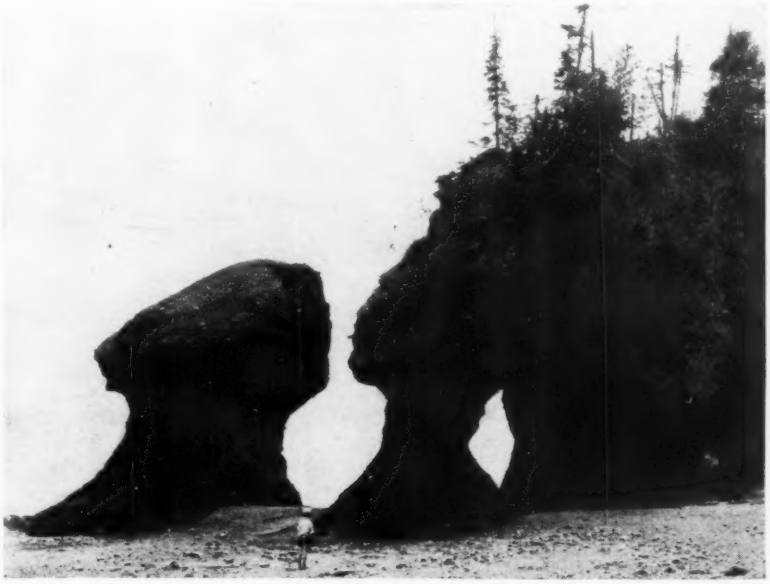
Compared to the vast tidal basins mentioned, the Passamaquoddy project sounds modest indeed. Its potential would be only 3 billion kilowatt hours a year. But this comes close to the power produced by Hoover Dam — about four billion kilowatt hours yearly. And it should be remembered that silt deposits will eventually put such dams out of operation. A tidal power plant, on the other hand, should continue to function century after century.

Canada and the United States are now making a complete study of the Passamaquoddy-Cobscook project. The outlook appears favorable. Passamaquoddy Bay, on the Canadian side, and Cobscook Bay, on our side, would both be used. Ten dams and a number of turbogenerators would furnish continual power.

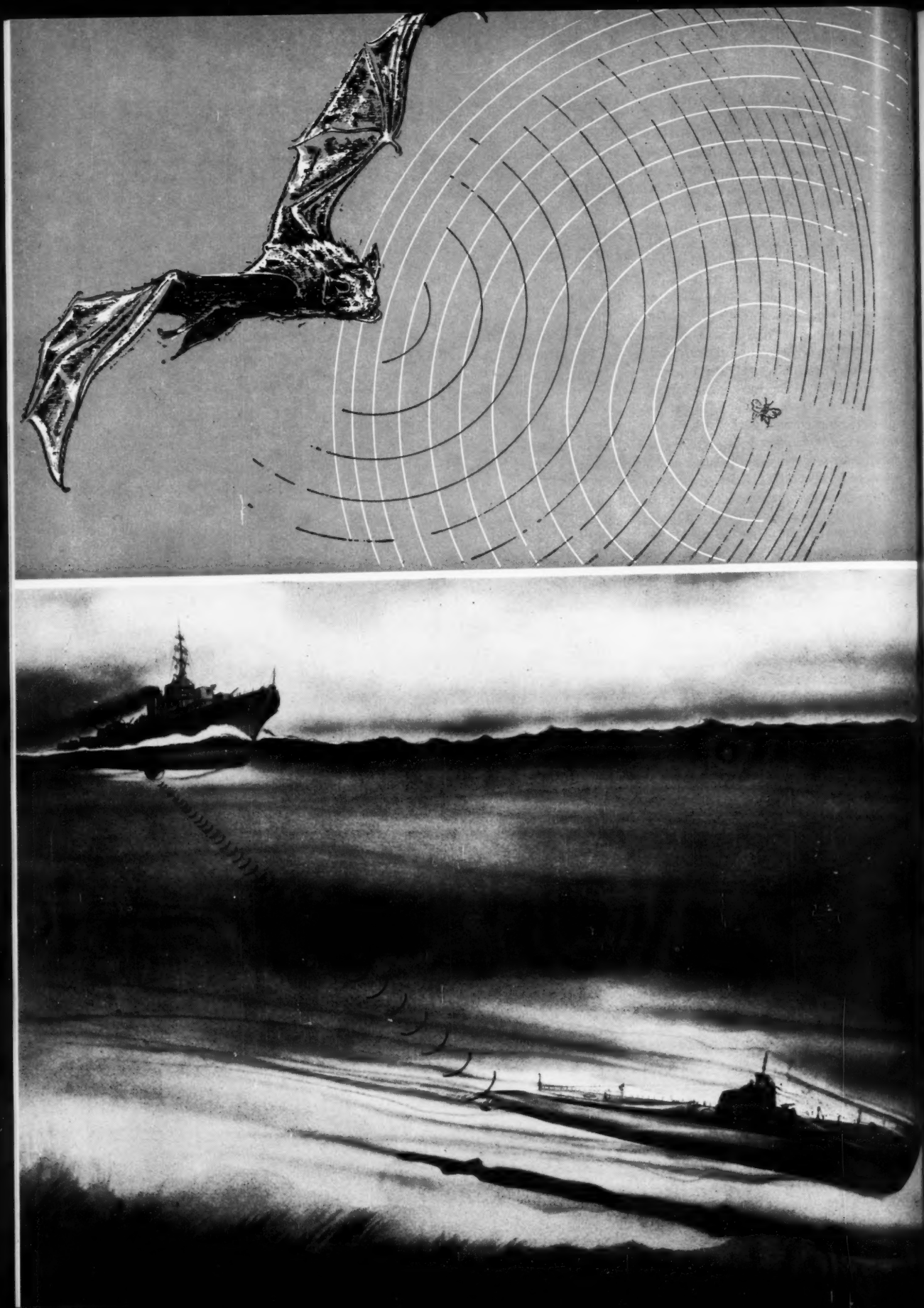
Engineers also have a follow-up plan in mind involving the 50-foot tides of the Bay of Fundy. These could deliver about 17 billion kilowatt hours per year.

It's true that the tides can never provide more than a fraction of the world's power needs. But long after coal, oil, and gas are gone, the tides will still be providing their power.

— New Brunswick Travel Bureau



ERODED ROCKS in Bay of Fundy show force of tides. High tide covers erosion marks.



By Roy A. Gallant

How bats 'see' by sound

In the blackness of night, some bats easily catch flying insects, thanks to a remarkable detection system that puts similar man-made systems to shame

For hundreds of years, bats have been creatures of interest — and sometimes of mystery — to the scientist. In the early 1500's, Leonardo da Vinci, the great Italian artist-scientist-engineer, marveled at the bat's structure. He even designed a "flying machine" with wings and tail section closely resembling a bat.

More recently, electronics engineers as well as zoologists have begun to regard the bat with new wonder. On the darkest of nights, many species of bats are able to find their way about, weave around obstacles, and even catch insects in flight. They do all this by "echolocation." A bat emits ultrasonic cries — cries of such high frequency that a human being's ear can't hear them. The sound waves leave the bat's mouth, strike and bounce off an object or insect in its path, and return to the bat's ears. The ears are so constructed that the bat can tell exactly how far away the object or insect is, whether it is moving, and, if so, the direction and speed of movement. Echolocation helps a hungry bat to catch hundreds of insects an hour.

Not many years ago, scientists looked on the echolocation system of bats as a rather crude "collision-warning device." But the more they learn about it, the more impressed they become. "Echolocation by bats is still such a new discovery that we have not yet grasped all its refinements," says Harvard zoologist Donald R. Griffin. Dr. Griffin and other scientists are now convinced that the electronics engineer can learn to improve sonar by studying bat navigation. Sonar is an echolocation system developed during World War II to detect enemy submarines. Dr. Griffin reports that the bat's echolocation system weighs thousands of times less than the smallest man-made sonar system. Yet, it is billions of times more efficient.

Among the first recorded experiments in bat echolocation was one performed in the 1700's by an Italian naturalist, the Abbé Spallanzani. His observations of bats in flight made him suspect that certain bats do not depend on their eyes to find their way about and to catch food. To prove this, Spallanzani performed a needlessly cruel experiment. First, he blinded some bats (he could have simply blindfolded them). He then released the bats in a room in which he had placed various obstacles. Flying around the room, the blinded bats avoided the obstacles.

Later, Spallanzani allowed the bats to fly about outside. After several hours, when the bats had returned to their home in a nearby bell tower, Spallanzani captured and dissected them. He found their stomachs filled with freshly caught insects. These two experiments told him that certain bats do not depend on their eyes for navigation or for catching insects. But the experiments did not reveal *how* bats find their way about.

For a century and a half, little more was learned about bat navigation. In 1920, a British biologist, Professor Hartridge of King's College, Cambridge, suggested that bats might use reflected high-frequency sounds to find their way about. One summer night, he was

'SILENT' SOUND enables a bat to locate an insect in the dark (*left, above*) and a ship to find a submarine beneath the surface (*left*). Bat and ship both send out sound waves of a frequency that the human ear can't hear. These waves are reflected from targets. Bat's ears and ship's sonar receiver pick up echoes.

Illustrations by William Bryant. Sonar illustration, courtesy General Electric Co.

working in his study. A bat, pursuing a moth attracted by the professor's lamp, flew in the window. He watched the bat weave this way and that, avoiding obstacles and passing with ease through partly closed doors as it flew from room to room. It flew equally well, the professor discovered, whether the lights were on or off. And when he closed a door to a narrow crack, the bat would fly up to the crack, but would not try to pass through it. Experiments with bats in a completely darkened room convinced Hartridge that the animals did not depend on their eyes for navigation. At the time, the professor was involved with experiments in vision. So he did not try to prove his navigation-by-sound-wave theory.

Twenty years later, Dr. Griffin and Dr. Robert Galambos, a physiologist then at Harvard, finally solved the riddle of bat navigation. Their first experiments confirmed the theory that blindfolded bats are not handicapped in flight. Next, they covered the ears of their laboratory bats. The creatures were reluctant to fly at all. When they did fly, they continually bumped into obstacles. If only one ear was covered, the bats did better, but they still collided with objects now and then.

The scientists' next step was to cover the noses and mouths of their bats, but to leave the ears free. In the previous experiment, the animals had been prevented from hearing the echo of the sounds they made. In this experiment, they were prevented from emitting the sounds. The result: more collisions. Here was conclusive proof that certain bats navigate by echolocation.

The scientists now used a special instrument to measure the sounds made by the bats. They discovered that certain bats emit ultrasonic squeaks nearly all the time. When they are in flight, the number of squeaks increases. The greater the squeak-rate, the more information the bat receives.

This raises a puzzling question: when a bat emits squeaks very rapidly, how do the animal's ears unscramble the echoes from the squeaks? Scientists think that a tiny muscle in the bat's ears puts things right. During each squeak, they suggest, the muscle contracts, preventing the bat from hearing the squeak. Then the muscle relaxes, enabling the echo to be heard.

In principle, the bat's "sonar" system is similar to the one designed by electronics engineers to detect enemy submarines. In submarine detection, a surface ship sends ultrasonic sound waves through the water. When these waves strike a submarine, they are reflected back to a receiver on the ship. The direction from which the echoes come indicates the position of the submarine. The length of time between the sending of the sound waves and the return of their echoes tells how far away the submarine is. Changes in echo direction and time of echo return indicate the sub's course and speed. Radar works in the same way, except that it uses radio (electromagnetic) waves, which do not pass through water easily.

Bats that use echolocation have specialized vocal cords. Very thin and stretched tight, these cords can emit high-frequency sounds of more than 50,000 cycles per second. This is well beyond the average human's hearing range (from about 20 cycles per second to about 20,000 cycles per second).

Bats can also emit cries of 5,000 cycles per second, which can be heard by the human ear. But low-frequency sounds such as these are not reflected nearly as well as high-frequency sounds. That is why high-frequency sounds are used in echolocation.

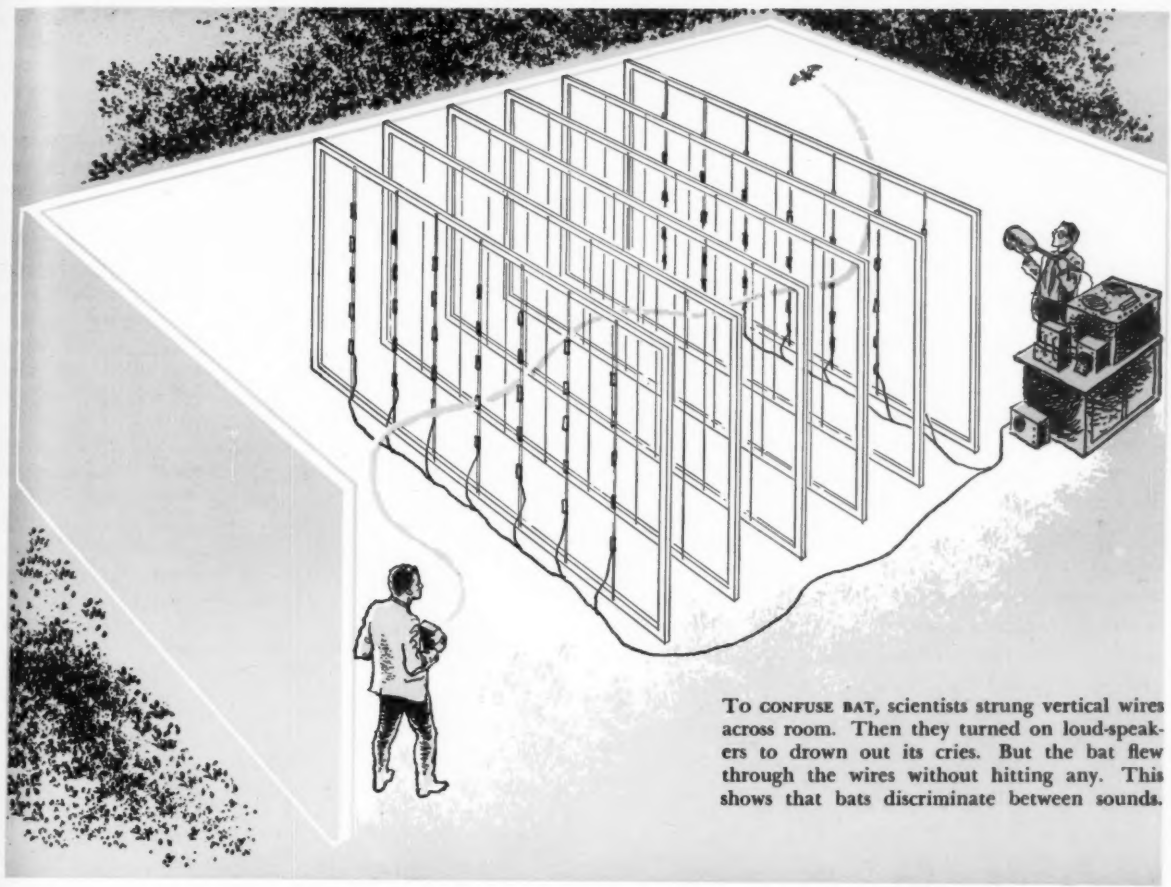
A good tape recorder will register the high-frequency squeaks made by a bat tracking its prey. If the tape recorder is then played back at a speed slower than its recording speed, the frequency of the sounds is lowered enough so that the human ear can hear them. They sound like clicks.

Zoologist Griffin used this technique on one of his field trips. He turned on a recorder as a big brown bat (*Eptesicus fuscus*) cruised overhead and locked onto an insect in flight. When Griffin played the tape back at a slow speed, this is what he heard:

"The [cruising] clicks sound like the slow put-put of an old marine engine. As the bat swoops toward a moth, the sounds speed up to the tempo of an idling outboard motor; and when the chase grows really hot, they are like the buzz of a model-airplane gasoline engine."

When the bat is cruising, according to Dr. Griffin, each put-put sound pulse lasts about 10 to 15 thousandths of a second. But when the bat begins to "home in" on an

HORSESHOE BAT *(left)* has special skin flaps on its nose that focus the animal's sounds in a sharp beam. By moving its nose flaps, the bat can sweep the beam around to locate objects. Bats are not birds, as some people think, but mammals. They are the only known mammals that fly. A bat's wing consists of a leather-like membrane stretched over five long "fingers." Some bats hunt by day and sleep at night, depending on their eyes rather than on an echolocation system. Bats are found in nearly all parts of the world. Those living in the north generally hibernate in winter, though some migrate south, as many birds do. Most species are small, having wingspans of about eight inches. But the "flying foxes" of Java have wingspans of up to five feet. Depending on the species, a bat may feed on blood (the "vampires"), insects, fruit, birds, even fish.



To CONFUSE BAT, scientists strung vertical wires across room. Then they turned on loud-speakers to drown out its cries. But the bat flew through the wires without hitting any. This shows that bats discriminate between sounds.

insect, the pulses come at a faster pace (about 200 per second) and become shorter (lasting only a thousandth of a second or so). This increases homing accuracy.

Not only can some bats vary the rate and length of their sonar pulses, but they can also vary the frequency of their cries. In other words, they are FM (frequency-modulated) bats! As a fleeing insect darts this way and that, its body presents a constantly changing shape to a pursuing bat. By varying the frequency of its cries, the bat receives a better "acoustic picture" by which it can track the insect.

One bat, known as the "horseshoe bat," has a specialized nose assembly that adds to the accuracy of its sonar. (See drawing, page 12.)

Dr. Griffin and others have tested the sensitivity and accuracy of bat sonar by stretching banks of fine wires across a room. They have then forced a bat to fly from one end of the room to the other. If wires are strung from wall to wall, the bat will fly through a much narrower gap than if the wires are strung from ceiling to floor. In the horizontal arrangement, the bat must time the flapping of its wings so they will not be in a raised or lowered position when it passes between two wires. Echolocation alone, it seems, gives the bat just the information it needs to navigate through this laboratory obstacle course. A European scientist, Sven Dijkgraff, found that echolocation also enables bats to distinguish between objects of different shapes.

In an attempt to confuse bats flying through banks of closely spaced wires, Dr. Griffin tried to jam their sonar signals. He did this by turning on loudspeakers, which "all but drowned out the bats' cries." But the bats seemed not to mind it at all. They still found their way through the wires — even though their direction-giving echoes were some 2,000 times fainter than the loudspeaker noise! Bats need this ability to discriminate between the sound they want to hear and "noise" they don't want to hear. Otherwise, imagine the chaos in a cave containing several thousand bats frightened into flight!

Echolocation, according to some scientists, operates in man to a certain extent. For example, during a heavy fog, ships' captains used to sound their fog horns periodically, using the echo to gauge how far away the shore was. It would be interesting to find out to what extent blind people consciously or unconsciously use echolocation as they tap their canes.

— Prints from Visual Discoveries

By Auguste Piccard

IN THE STRATOSPHERE

Balloons and the Space Age: *Balloonists are among the great pioneers of the Space Age. Long before man was able to send up rockets and satellites, balloons were exploring miles above the earth. They are still exploring, bringing back reports and observations that will one day help man to rocket into space. Among the great names in ballooning is that of Auguste Piccard, Swiss-born professor of physics and first man to reach the stratosphere. Here, in his own words, is the story of that famous launch, made in 1931*

C

Early balloon history
In 1783, ballooning was born in France. On June 5, the Montgolfier brothers launched the first balloon, filling it with hot air from a fire (*A*). August 27: Physics Professor J. A. C.

From the beginning of the last century it had been noticed that gases reputed to be perfect insulators for electricity could in reality, in certain conditions, conduct it. It had been observed, in particular, that the passage of electricity through the gases was possible when these gases were exposed to the radiation of radioactive bodies. But, what was surprising, these observations made in a balloon, for the atmosphere at altitudes of 2½ miles to 5 3/5 miles, revealed an increase of conductivity, while, as the distance from the earth and its radioactive bodies increased, it had been expected that a decrease would be observed. This led physicists to adduce the existence of another phenomenon, that of cosmic rays coming from outer space.

It was to enlarge our knowledge in this domain that I, a physicist, conceived the idea of ascending into the stratosphere.

Let us recall in a few lines what this word signifies. The higher we rise in our atmosphere, the lower are the temperatures we encounter. But, as Teisserenc de Bort discovered by means of his sounding-balloons, between 3¾ miles and 10 miles, according to the latitude and the season, we encounter a very marked limit beyond which the temperature ceases to fall, or even increases slightly, with the altitude. Here, from the meteorological point of view, begins the stratosphere, the region where the vertical displacements of air, which produce the condensation of water and the formation of the clouds, no longer exist. Thus the stratosphere is rightly termed the region of perpetual good weather. It is because it commences at 7½ miles, as an average in our regions, that aviators in their everyday usage give this altitude as its lower limit.

It was to this high region — or, to be more precise, to an altitude of 10 miles — that I wished to ascend to meet the cosmic rays in order to observe them in mass, where their initial properties would not yet have been too modified by collisions with the molecules of our atmosphere.

For a number of investigations, use had been made of sounding-balloons, the classic free balloon scarcely allowing man to do useful work beyond 3¾ to 7⅜ miles. Beyond this range, in fact, the air is too rarefied for our organism, and even if the aeronauts have an equipment permitting them to breathe pure oxygen, they cannot stay for long above about 7½ miles. The sounding-balloon was thus, for meteorologists, the sole means of exploring the high atmosphere. A generation had laboured to devise automatic instruments for recording pressure, temperature, and humidity. But the measurement of cosmic rays was a delicate operation very different in nature, and could not be effected at the time with the necessary precision by these automatic instruments. That is why I decided to ascend myself to 10 miles. Luckily I was licensed as a free-balloon pilot and I had already made a dozen ascents. May

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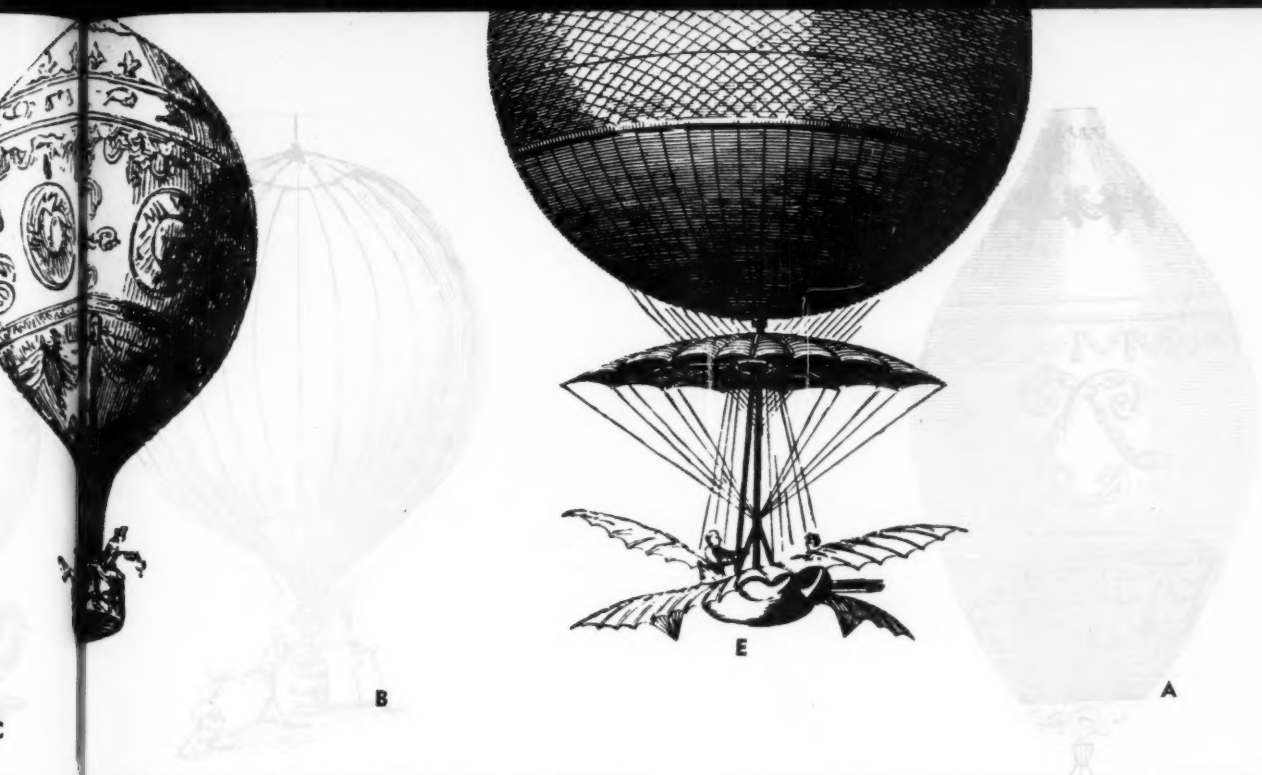


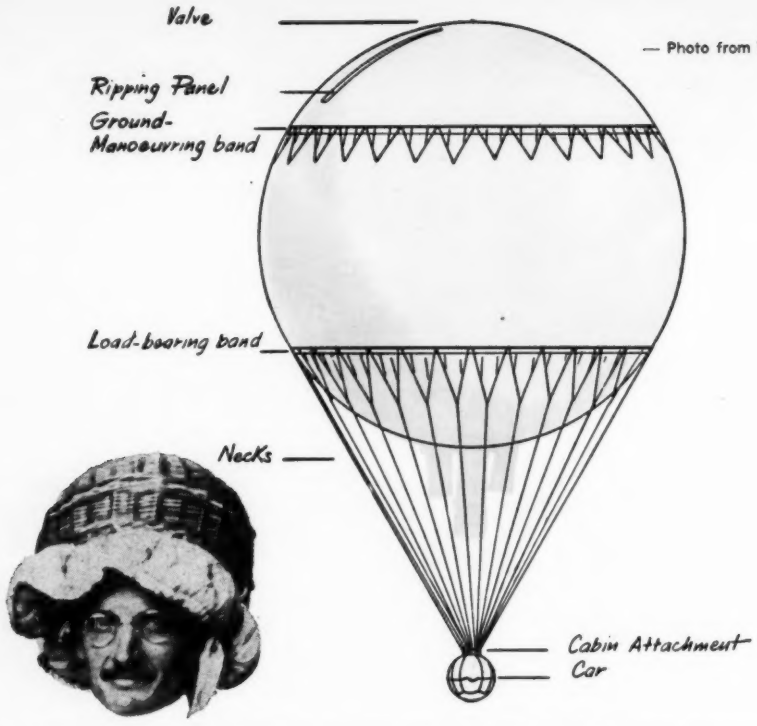
Charles sent up a hydrogen-filled balloon (*B*). September 19: The Montgolfiers sent up the world's first balloon passengers — a sheep, a duck, and a rooster — who descended safely (*C*). November 21: The world's first human passengers, De Rozier and D'Arlandes, went up and came down safely (*D*). Ascents in many countries followed. First balloon trip in America was made in 1793 by Frenchman Blanchard (*E*), carrying first airmail letter, written by George Washington. Blanchard had previously crossed the English Channel in a balloon.

I here relate how I became an aeronaut?

Like most young men of my time, I had a passion for everything related closely or remotely to this new science. It was the epoch when the heavier-than-air machine was making its first essays and when only optimists foresaw the future development of aviation: the lighter-than-air machine was still king of the sky. As a young physicist I naturally read all the aeronautical journals within reach. A question was being discussed in them by specialists: that of the distribution of the gas temperatures in the interior of spherical balloons. Now, I did not agree with the published results. These seemed to me to be in contradiction with theory, and this was explained by the fact that the method of measurement chosen was not suitable. It was necessary to take the measurements again in better conditions. I addressed myself to the Swiss Aero-Club (Aero-Club de Suisse) which, understanding the importance of the problem, permitted me to make several ascents with this scientific object. These were my first trips. I had in the interior of the balloon, along its vertical axis and also in the neighborhood of its equator, a dozen electric thermometers, thermocouples whose cold junctions were in the basket of the balloon. I myself constructed a simple and exact potentiometer, and by means of an Einthoven galvanometer I could measure the temperatures of the gas within approximately a tenth of a degree. At the same time I could, by means of a rubber tube, take samples of gas from different parts of the balloon when it was at different heights and from them determine the density by means of a Bunsen apparatus. This permitted me to follow the diffusion of the air coming in through the neck and being slowly mixed with the gas. All these measurements were made for daytime and for nighttime at different altitudes, so as to show more clearly the influence of solar radiation.

These studies familiarized me with the balloon. I did not then think that later they would lead me into the stratosphere.

I have said that it was the study of cosmic rays which had led me into the stratosphere. As a matter of fact I had also another reason for going up there myself: I wanted to induce the air services to use the high atmosphere, to travel at high speeds at an altitude where the rarefied air offers less resistance. But since, in the stratosphere, the low pressures make human life impossible, I was going to have to make use of an airtight cabin permitting the maintenance of an almost normal atmosphere. The specialists of those days considered my suggestion as unrealizable. What today appears elementary to us, in those days seemed Utopian. But the single objection that they were able to make to me was that up till then no one had ever done it. How often have I heard reasoning of this sort! But it is just the function of the engineer to place his reliance



— Photo from Wide World. Drawings pps. 16, 17 by Wes McKeown

DIAGRAM SHOWS the stratospheric balloon *FNRS* designed by Professor Auguste Piccard. He wore a crash helmet, something like a padded wicker basket.

upon theory when creating something new. If I had been an aviator I should perhaps have constructed, at the beginning, a stratospheric aeroplane. But being an aeronaut I plunged into the construction of a balloon. It was besides relatively simple to suspend an airtight cabin to the free balloon.

The Belgian National Fund for Scientific Research (*Fonds National Belge de la Recherche Scientifique*), which had just been founded by King Albert I, supported my project and accorded me the necessary credits. In homage to the *Fonds National* the balloon was baptized the *FNRS*.

I wanted to ascend, as I have said, to meet the cosmic rays at a point where they would not yet have traversed more than a tenth of the atmospheric mass. Now, at such an altitude the pressure is, naturally, no more than one-tenth of an atmosphere. In other words, at this height the pressure of the air is no more than a tenth of that we experience at sea level. As the lifting force of a balloon is proportional to the density of the air displaced, as Archimedes would have already told us, I had thus to construct a particularly large and light balloon, so that it could carry observers, instruments, and the airtight cabin.

I spare the reader the calculations I made: I had to have an envelope of 223,560 cu. ft., of 114 ft. in diameter, made of a material of the least possible weight. Here arises the principal difficulty in the construction of stratospheric balloons: a balloon of this volume, completely inflated with hydrogen, would have at its take-off a static lift of nearly 16 tons. To resist this force, material and net would have to be extraordinarily strong, and thus heavy — so heavy that the balloon would never reach 10 miles, where a cubic yard of hydrogen supports only one-tenth as much as it does down here. To permit the use of a light envelope, then, it was necessary to introduce into our balloon, at the moment of take-off, only a small part of the gas that it could contain, one-fifth of its maximum volume. During the ascent this gas would expand under the effect of the decrease of atmospheric pressure and only in the stratosphere would the envelope take its spherical form.

Which of my readers has been present at the rigging of a spherical balloon? The envelope is spread out on the ground like a cast-net. Upon it the net is disposed. The gas is introduced. The envelope dilates and lifts up the net, which is held (and stretched) by bags of ballast. As the volume of the envelope increases, the bags are taken from mesh to mesh to be hooked on lower down. During this whole operation care must be taken that the folds in the expanding envelope open out completely, without being caught in the folds of the net. When the envelope has become spherical and has attained the desired height, the ropes attached to the net are affixed to the hoop, and the balloon is prepared for the ascent. All this is accepted practice.

But our *FNRS* was to receive at the beginning only a small part of the gas which would later inflate it entirely. It was thus only the upper portion which would contain gas, the rest of the envelope remaining empty and hanging in great loose folds which would be progressively filled during the ascent. In these circumstances what was to be done to avoid the accidents arising from folds partially retained in the net? We could not count upon a procession of guardian angels to release the folds during the ascent; and as we would not give up the envelope, we were obliged instead to give up the net. It was therefore necessary to suspend the car directly to the envelope by a belt.

Designing a sealed cabin

Let us now look at the basket of our balloon, or rather at what it had instead of a basket. We must have a hermetically sealed cabin carrying breathable air at ordinary pressure, and able to resist this internal pressure even when the outside pressure will be no more than one-tenth of an atmosphere. Our lives depend upon the airtightness and the strength of this cabin. Let us, then, have a spherical cabin in sheet aluminum of one-seventh of an inch (3.5 mm.) thick. The diameter will be 7 ft. (210 cm.). Two observers, surrounded by their instruments, will be perfectly comfortable here, surveying the outside world through eight round port-

holes of a convenient diameter, that of 3.5 in. (8 cm.). To avoid the danger of breakage caused by the difference between the pressures prevailing on the two faces, these windows are constructed of two sheets of glass, each 0.3 in. thick, separated by a thin layer of air which contributes to thermal insulation. We thus prevent the formation of rime on the windows, even in the stratosphere, where the external temperature is in the neighborhood of −76° F. These windows offer no danger of breakage even when obliged to sustain a difference in pressures of nine-tenths of an atmosphere.

Piccard air lock

How could we, from this sealed cabin, manage to drop ballast without air escaping? The principle of the air or water lock is well known. Here is how, when I was still a child, I observed its functioning for the first time. One day I was taken to visit a menagerie. In one of the cages was a lion and a lion-tamer. How would the tamer get out without the lion being able to follow him? It was a revelation for the little lad that I then was: the tamer went into a little adjoining cage through a door which he closed behind him: only after this did he open a second door which gave him access to the outside: at no time were the two doors open at once and the beast had not been able to get out. Forty years later I had not forgotten this scene. The tamer was now the ballast, which had to get out of the cabin without allowing the lion, that is, the air, to follow it.

It was sufficient to apply the principle of the air chamber: let there be a container provided with two straight-through taps. By means of a funnel, we pour the ballast into the container through the upper cock, the ballast being composed, in our case, of lead shot. Then, after this cock is closed, the lower cock is opened and through it the ballast pours directly towards the outside. So that the lead shot in falling might not injure spectators, a very fine shot is needed. I made sure myself that there was no danger by standing at the bottom of the big chimney of the University of Brussels under a rain of shot which was poured on my head from a height of 156 ft.

All would have been for the best if international regulations had permitted anything other than sand or water for ballast. What was to be done? To cut all discussion short, I declared that I had as ballast lead sand. This explanation aroused no objection. However, by definition, sand is a non-metallic substance and nobody has ever seen lead-sand.

Augsburg, September, 1930. On the 14th September the balloon was inflated. Knowing that the wind would hinder the rigging of this large balloon and could even render departure impossible, we had waited several weeks for favourable weather forecasts. But to our great despair, the weather changed abruptly, a violent wind took a hand, and we had to empty the balloon and give up the idea of departure. A great disappointment, it goes without saying, for the public and the press!

We waited once more for a more clement sky, but in vain. We had to wait until spring, winter not being a season favourable to an experiment of this sort. Finally, on the 26th May, 1931, the weather forecasts were favourable. In the night of the 26th-27th May, 1931, we got the balloon inflated: 100,000 cu. ft. of hydrogen. But on the morning of the 27th the wind rose once more and knocked the balloon about: the cabin was thrown out of the transporter and put slightly out of shape (later we were to notice the consequences of this). However, with my friend and collaborator, Paul Kipfer, I went into the cabin and we closed the manhole behind us. The wind increased. To hold the balloon, they attached, without my knowledge, a supplementary rope to the hoop. At 3:57 P.M. Kipfer, looking out of one of the portholes, said to me:

"A factory chimney is passing underneath us!"

They had let the balloon go and forgotten to give us the signal of departure that had been agreed upon!

We went up very quickly. Some moments afterwards, I perceived that the insulator of an electric sounder going through the wall of the cabin was broken at the time it fell: the air — our precious air — was rushing out, whistling through the hole. Fortunately, I had had prepared a mixture of tow and vaseline, expecting that this paste would be useful in case of a leak. I surrounded the insulator with insulating tape and with this paste. The work was not easy.

Soon Kipfer, who was observing the pressure gauges, said to me:

"We are at 2½ miles and there is still an equal pressure inside and outside the cabin!"

Emergency in the sky

Well, why have I had this beautiful aluminum cabin built? Since it leaks like a basket, a simple wickerwork car would have been as serviceable! The situation was critical. I said to my companion:

"If we don't become airtight immediately, we must pull the valve and land, if we don't want to suffocate." We didn't yet know that the rope of the valve was blocked.

Both of us confident in this last resource, I went on with my work. But the hole was big! Bit by bit, however, the whistling grew feebler, then was silent. Never have I appreciated silence so much. The pressure already in our little home had gone down to less than two-thirds of normal. Happily, we had a reserve of liquid oxygen. I poured some of it on the floor in small quantities, and the oxygen rapidly evaporating increased the pressure.

We still went up. The sky became darker.

Twenty-five past four! Twenty-eight minutes ago we were still in Augsburg, 1650 feet above sea level.

"What altitude, Kipfer?"

"51,200 feet."

In less than half an hour we had gone up over 9 miles. The balloon, whose shape at the moment of departure was rather that of a dried pear than of an apple, had now inflated following upon the expansion of the gas and had become perfectly spherical. The excess gas escaped by the neck and our aerostat reached its first position of equilibrium.

[*To be concluded next issue*]

Science in the news

Scientists probe sea for prehistoric snail

Scientists from Columbia University have gone snail-hunting. They're probing the seas off South America in search of a snail called *Neopilina*.

Unlike most animals, this snail apparently has not changed physically since the time its first ancestor appeared 300 million years ago. Only one of its kind has been found before; that one was embedded in rocks. Now scientists hope to bring one up alive. If they do, they will study its life cycle to get an idea of how life developed in prehistoric times.

Scientists believe *Neopilina* has remained unchanged because it has lived in deep-sea trenches. There the snail would have been shielded from radiation. Radiation – by causing mutations – has gradually changed the physical traits of animals through the ages.

The scientists are also looking for other deep-sea animals. They will study the relationships between such animals found in the Caribbean Sea and the Pacific Ocean. They hope the study will disclose information about a waterway that connected the Caribbean and the Pacific Ocean millions of years ago.

Next two lunar probes will be made by the Army

The Army is scheduled to make the next two U.S. moon shots. The first will probably be made in early December, the second some four weeks later. The first three lunar-probe attempts of 1958 were made by the Air Force. Its third try, made early in the morning of November 8, failed when the third-stage engine did not ignite. The rocket, which had reached an altitude of about 1,000 miles, burned up over Africa.

Navy uses soot to make clouds come and go

A woman scientist has shown the Navy how to make clouds appear and disappear. She is Dr. Florence W. van Straten of the Naval Weather Service. Dr. van Straten's "magic wand" is a soot called carbon black. Carbon black is similar to the soot that forms on the mantle of a kerosene lamp.

To make a cloud, particles of carbon black are "sown" at the altitude where the base of the future cloud is to be. To dissolve a cloud, the soot particles are released at the cloud's top. It then disappears in minutes.

The secret of carbon black's effectiveness is that it absorbs heat. When the soot is scattered in moist, cloudless skies, its particles absorb heat from the sun and warm the air around them. The warm air rises and expands. As it cools at higher levels, its moisture condenses. Thus, a cloud is formed. There must be moisture in the air, of course. A cloud couldn't be produced over the Sahara Desert.

A cloud is dissolved when carbon-black particles enter some of its droplets, but not others. The soot's heating powers warm the droplets they enter, causing their moisture to evaporate. The unwarmed droplets that don't contain soot collect this moisture. They expand until they become large enough to drop as rain.

Dr. van Straten describes herself as a "weather-modifier." Her aim is to find a way to banish fogs and thunderstorms, destroy tornadoes, and divert hurricanes from their destructive paths. She makes no claims that the carbon-black method is ready to do any of these things. More research and testing are needed before the fluffy soot can be rated as even a promising rainmaking agent. But the future of cloud control looks bright.

Satellites draw picture of radiation in space

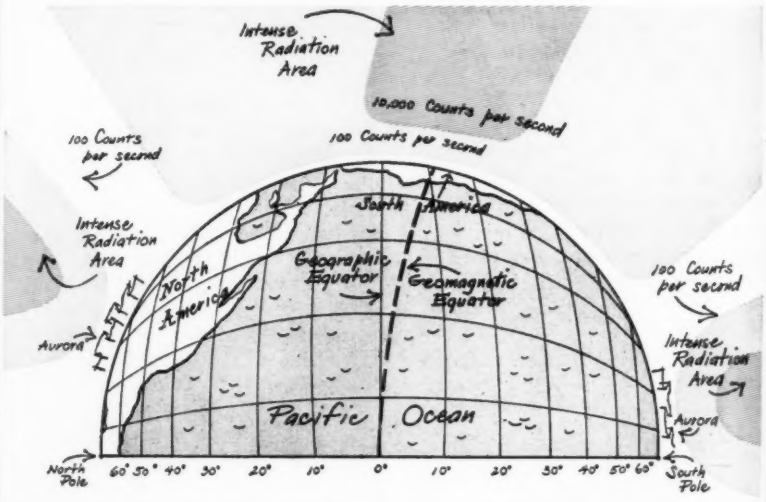
A clearer picture of radiation in space is being formed from data gathered by the Explorer satellites. It may take a year to analyze this data. But, so far, scientists have been able to construct a radiation diagram (see below). It shows a symmetrical pattern of intense radiation beginning at about 1,100 miles or more above the earth's geomagnetic equator. This equator is a circle formed by points on the earth's surface that are equidistant from the magnetic poles.

The data suggests that the intense radiation extends to about 12,500 miles above the earth's surface. It also suggests that other areas of heavy radiation exist above areas near the magnetic poles.

Contrary to first reports (see *SW*, November 11), the Pioneer lunar rocket added little knowledge about radiation in space. No usable radiation data appears to have been received from it below an altitude of 18,000 miles. At that altitude and above, the rocket was beyond the radiation zone. Readings were zero.

Until it reached 18,000 miles, the rocket's radio signals were not received clearly. On the way back toward the earth, Pioneer's batteries went dead. So no signals were sent.

—Drawing by Wes McKeown



Radiation pattern suggested by Explorer satellites is shown in cross-section. Cores of intense radiation appear above geomagnetic equator and above areas near poles.

What is Harvard doing with all that rock?

Five tons of rock recently arrived at Harvard University's Museum of Comparative Zoology. Embedded in the rock were ancient bones – bones that rank as one of the world's greatest fossil finds. Harvard paleontologists discovered the fossils in a desert valley in Argentina.

Some of the fossils are 170 million years old, dating from the Middle Triassic period. They are the remains of the common ancestors of dinosaurs, flying reptiles, and crocodiles. Others represent stages in the development of mammals from primitive reptiles. Still others belong to a type of reptile that had features in common with mammals. It looked like a cross between a dog and a lizard.

Why so many fossils should be found in Argentina is a mystery. Only in eastern Africa and southern Brazil have remains of land animals of this type been excavated. The fossil types range in size from a few feet in length to the size of an ox. Study and preparation of the bones for display will take several years.

Operation Snuffles gets under way in antarctic

The never-ending battle against the common cold is being fought on a new front – Antarctica. Fifty volunteers are serving in the campaign, called Operation Snuffles. They are acting as human guinea pigs to help prevent severe cold epidemics among those returning from the polar region.

Colds are normally not a problem in Antarctica. No cold viruses seem to exist there, except those brought in. But when polar explorers meet relief parties or return to civilization, an outbreak of colds is almost certain. Scientists think that the antarctic experiment offers an excellent opportunity to isolate and identify the viruses responsible.

The scientists will carefully study the fifty volunteers, taking frequent swabs of their throats and blood samples over a seven-month period. Due to the isolation of Antarctica, the virus population already in the men's throats is expected to decline steadily. Then, when the isolation ends and the inevitable cold outbreaks occur, the scientists will look for any new viruses that have appeared. These will probably be the culprits. Knowledge gained from the experiment may be useful in the fight against the common cold. (For more on the common cold, see "News in Brief.")

Scientists are also investigating why antarctic animals seem to be free of harmful bacteria. An antibiotic substance recently discovered in the plant life of the frigid waters may be the answer. These plants are the basic food of the region. So the antibiotic substance would eventually find its way into the bodies of the animals.

These two studies are among hundreds being carried out in Antarctica by scientists who are there for IGY. After IGY ends on December 31, the U.S. will continue to participate in the studies. The effort will then be directed by the National Science Foundation and the National Academy of Sciences Committee on Polar Research.

Within the next two years, the U.S. may set up the first nuclear power plant in the antarctic. The cost would be from $4 to $5 million. But the power plant would probably pay for itself in about three years by providing less expensive heat and power. Nuclear power might also be used to extract mineral deposits locked under the polar ice mass.

Studies raise hopes for cancer vaccine

Scientists hope someday to develop a cancer vaccine, as they did a polio vaccine. This hope has been brought closer to reality by two recent research experiments.

One experiment supports the theory that viruses cause some forms of human cancer. Virus-like particles were discovered in cancer of the human colon (part of the large intestine). These particles were a thousandth of the size of bacteria. They were also found in a disease (ulcerative colitis) that is considered a forerunner of cancer of the colon. Though not actual proof, this is strong circumstantial evidence that a virus can cause some kinds of human cancer.

In the other experiment, a vaccine was developed to prevent a type of virus-caused cancer in mice. (Viruses have been shown to cause various types of cancer in mice, dogs, rabbits, horses, and other animals.) This is the third vaccine that has proved effective against animal cancer. This experiment began two years ago when a team of researchers reported the discovery of a virus that caused cancerous tumors in mice. Researchers prepared a vaccine from this virus. One group of mice was given the vaccine, then injected with the virus. Only 3 per cent developed cancer. Another group of mice received the virus alone. Of these, 67 per cent developed cancer and died within five months.

News in brief

● Three Soviet physicists, a British biochemist, and three U.S. geneticists won 1958 Nobel Prizes. Dr. Pavel A. Cherenkov, Professor Ilya M. Frank, and Academician Igor Y. Tamm shared the physics prize. Their research had led to the discovery of atomic particles and had spurred the study of cosmic rays. The chemistry award went to England's Dr. Frederick Sanger for his work on the structure of proteins. The three U.S. geneticists were jointly honored for their contributions to physiology and medicine. Dr. George Wells Beadle and Dr. Edward Lawrie Tatum shared one-half of the prize for discovering that genes transmit hereditary characteristics by controlling chemical reactions. The other half of the prize went to Professor Joshua Lederberg for research on the relationship of bacteria to genetics.

● "Crocodile tears," as we use the expression, means insincere sorrow. It comes from the old fiction that crocodiles weep over their victims. However, two biologists have now found that crocodiles *do* weep. But the weeping is not in sorrow – it helps the animals rid themselves of excess salt. Both crocodiles and sea turtles have special glands in their heads that extract some of the large amount of salt in their bodies. The glands empty the tearlike wastes into the eyes.

● The British Commonwealth will build a telephone system that will provide instantaneous communication around the world. The vast, globe-encircling network will be laid in the next ten years at an estimated cost of $250 million. It will provide telephone, cable, and photo-telegram service.

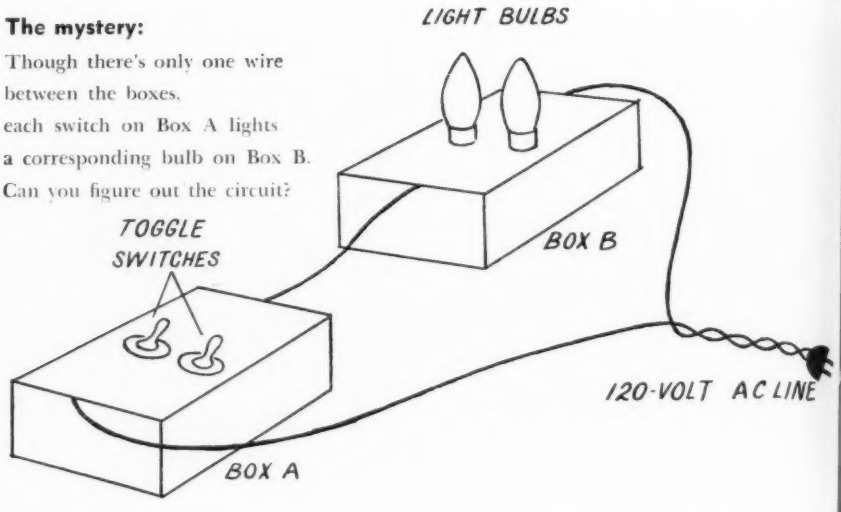
● A fly has been discovered that is far more lethal to grasshoppers than any insecticide. The fly uses a fanglike tube in its abdomen to plant eggs in a grasshopper's leg muscle. The larvae that hatch from the eggs slowly devour the grasshopper. In one part of central California the parasitic fly virtually wiped out the grasshopper population. Scientists plan to export the fly to regions where grasshoppers are a major threat to crops.

● A new vaccine against the common cold is now being tested on people. It's a combination of at least eight vaccines, each aimed at specific viruses that cause colds and coldlike illnesses. Scientists haven't yet discovered all the viruses that cause man's colds. But the new vaccine is an attempt to knock out those viruses that seem to cause the most colds.

Young scientists

MORE SELF-STARTERS

The mystery:
Though there's only one wire between the boxes, each switch on Box A lights a corresponding bulb on Box B. Can you figure out the circuit?



Culturing brine shrimp

"A million eggs for 49¢ — each alive and guaranteed to hatch!"

You might see such a sign in any pet store that sells tropical fish. The eggs are those of the tiny brine shrimp (scientific name: *Artemia salina*). These eggs are sold to tropical fish fanciers who hatch them to provide live food for their fish. But if these people ever stopped to study the brine shrimp, they would probably find it more interesting than tropical fish.

Brine shrimp are small crustaceans. When mature, they are about a quarter of an inch in length. They resemble, in miniature, the shrimp we eat. As an object of study, they are most unusual.

You can buy a vial containing about a million dried, resting, brine-shrimp eggs in almost any tropical fish store. And you can raise these shrimp any time you wish — whether it be summer or winter. If you would like to try it, here are some suggestions:

Hatch the eggs by simply placing them in sea water. If you can't get natural sea water, you can do one of two things. You can buy a box of natural sea salt (in the same pet shop) and make up a gallon or so of sea water by following the instructions on the box. Or, if the sea salt is not available, you can prepare artificial sea water by adding three to four grams of table salt (not iodized) or rock salt to a liter of pond or aquarium water.

Fill a wide flat pan to a depth of an inch or two with the sea water (natural or prepared). Put in one-half teaspoonful of dried brine-shrimp eggs. If the eggs are put in a fish feeding ring, they will not scatter. Keep the pan at room temperature. In about two days, the eggs will hatch into larvae. Remove some larvae with a medicine dropper, transfer them to a microscope slide, and examine them under the microscope. They are almost completely transparent. All internal organs are quite visible. Be especially sure to note the eye spots on the head.

A few days later, the larvae will have matured into adults. These have ten to thirty pairs of leaflike swimming limbs. The adults, too, are transparent. Their circulatory and digestive tracts can be traced very readily under the microscope. The shrimp can be fed algae scrapings from the sides of an aquarium.

Brine shrimp are unusually sensitive to light — a fact that can make them useful in a great number of projects. Try covering all except one end of the bowl with black paper, and note how rapidly the shrimp clump together at the lighted end. They will always orient themselves so that the ventral surface (the underbelly) is toward the light. Thus, they often swim with the ventral region up.

In the female, you will probably notice egg pouches, one on each side. After each molting, the females mate. Eggs are laid as often as every four or five days. The eggs can be dried and may be kept for years before they are hatched.

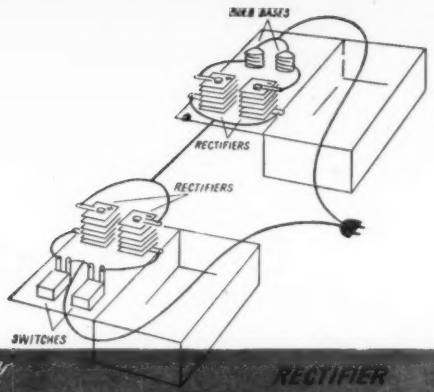
When you are through culturing your brine shrimp, remember this: if you strain the water through a piece of cloth, you have a meal fit for a fish!

Black boxes mystery

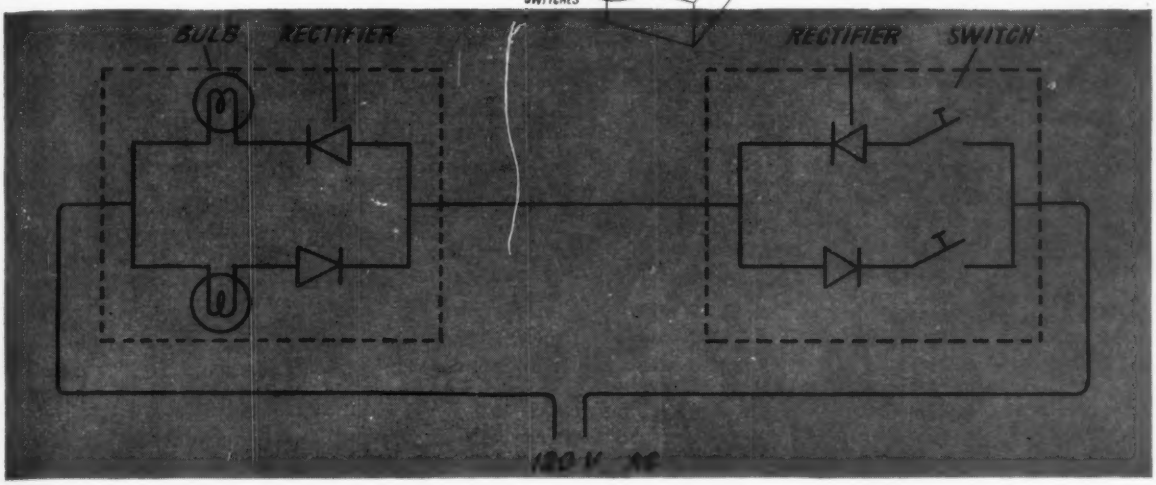
Try the "black boxes mystery" at your next science club meeting. You show your friends two small black boxes. Atop one of the boxes are two light bulbs. The other box shows nothing more than two toggle switches. There is *one* wire connecting the two boxes, and one wire from each of the two leads of a 120-volt A.C. line is connected to each box (see above). Snap on one switch on the first box.

The solution:

How the boxes look when opened (*top*) and their circuit (*bottom*).



Drawings by LoCurcio



One of the bulbs on the other box lights. When you flip the other switch, the other bulb goes on. Each bulb may be put off or on by means of its appropriate switch. But how can this be done when there is only a single conductor connecting the two boxes?

Ask your friends to deduce what is in the boxes and to draw the circuit. Unless you have some real geniuses in your club (or unless they have seen this article), you will witness the wide variety of ways in which humans try to solve a rather frustrating problem.

Actually, the circuit is not a very complicated one. It depends on the action of four small selenium rectifiers similar to those used in modern radio receivers. These rectifiers have the property of allowing current to flow through them in only one direction. One pair is arranged so that the two rectifiers pass current from the switch box to the light box. The other pair passes current only in the opposite direction. Thus, when a switch is closed, the current flows in only one direction and lights only the bulb in that circuit. When the other switch is closed, the other pair of rectifiers allows the current to flow through their bulb.

If you want to make a pair of "black boxes," all you need are: two single-pole, single-throw switches; four 100-milliampere selenium rectifiers; and two 7½-watt bulbs similar to those used in Christmas tree lights. Don't use larger bulbs, since they will overload your rectifiers. Incidentally, the principle of the rectifier, illustrated by the "black boxes mystery," can be adapted for use in many projects.

Putting a satellite in orbit

Have you ever been asked questions like these: How can an orbiting artificial satellite continue to circle the earth when it is actually falling toward the earth all the time? Why must the satellite's velocity be around 18,000 miles an hour?

In explaining, you may have become bogged down in a discussion of centrifugal and centripetal force. Next time, try it the following way. All you need is one fact and one formula. The fact: in one mile, the curving surface of the earth drops 8 inches from the horizontal line.

Now, suppose a projectile were shot horizontally just above the surface of the earth so that it could cover one mile in the same time that it took to drop 8 inches. Then it would end the mile exactly as high from the surface as it was when it was shot. How long would it take for the projectile to drop 8 inches? If you know the physics of falling bodies, you are aware that the distance, s, that a body falls in a time, t, is given by the formula $s=\frac{1}{2}gt^2$. Here, g (acceleration due to gravity) equals 32 feet per second per second. Substitute 2/3 foot (8 inches) for s and 32 for g. You will find that it takes about 1/5 of a second for a body to fall 8 inches. Therefore, if our projectile could cover a mile in 1/5 of a second, it would wind up just as far from the surface of the earth as it was when it was shot. Covering a mile in 1/5 of a second means a velocity of 5 miles per second. Since there are 3600 seconds in an hour, this is 18,000 (5 x 3,600) miles an hour.

Use the same reasoning to calculate the velocity required for a satellite to stay in a circular orbit far above the earth. Remember two points: (1) if a satellite is to remain in a large orbit, its drop per mile must be smaller; and (2) g becomes smaller as a body moves away from the earth's center.

A classroom display, in the form of a chart or model using the information above, will help others to understand the mechanics of earth satellites.

— THEODORE BENJAMIN

On the light side

Brain teasers

Double date

Mr. Smith's age this year is exactly the same as the last two digits of the year in which he was born. Surprisingly, the same coincidence applies to Smith's grandmother. How old is each of them?

Double image

A certain magnifying glass exactly doubles the size of all objects seen through it. If one looks through this glass at a 37-degree angle drawn on a sheet of paper, how large will the angle appear?

Tongue twisters

The *Journal of Heredity*, September-October, 1952, reported on four feats of tongue gymnastics and concluded that the ability to perform them is hereditary. The feats are:

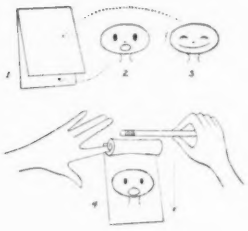
1. Curl the sides of your tongue upward, without the aid of your lips, to make a tube. Most people can do this.

2. Roll the tongue from side to side like a rolling pin, first raising one side of the tongue and depressing the other, then twisting the tongue the same way in the opposite direction. One in three can do this.

3. Fold back the tip of your tongue so that it lies flat on the tongue and stays there without aid from your lips or teeth. Three in one hundred can do it.

4. With the tip of your tongue, form the clover leaf shown above. Again, three in one hundred can do this.

Apparently, only those who can do the second stunt can do the last one. No one, the *Journal* states, has yet been found who can do all four.



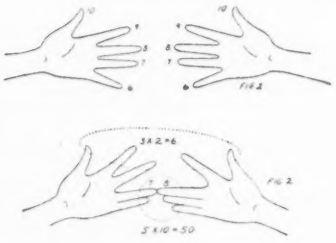
Paper movies

Cinematic motion is an illusion produced by a series of still images flashing rapidly across the screen. The principle is strikingly demonstrated with this paper toy.

Fold in half a paper rectangle, three by eight inches (Fig. 1). On the lower leaf draw the face shown in Fig. 2. On the upper leaf, draw the face in Fig. 3. Roll the upper leaf into a tube (Fig. 4).

Your left finger holds the upper left corner to a surface, while your right hand holds a pencil above the curled leaf, as shown. Move the pencil rapidly up and down, causing the curled leaf to unroll and roll up again. An amusing motion-picture effect will result.

Drawings by Gloria LoCurcio



Digital computer

In parts of Russia, peasants still use their fingers as "digital computers" (an appropriate name!) for multiplying numbers from six through ten. The method is interesting. Want to try it?

Mentally number your fingers from six to ten, as shown in Fig. 1. Suppose you wish to multiply seven by eight. The tip of a seven-finger (on either hand) is placed against the tip of the eight-finger on the other hand (Fig. 2). The touching fingers, together with all fingers below them on both hands, represent tens. In this case there are five such fingers. Five tens are fifty.

The next step is to multiply the number of remaining fingers on the left hand by the number of remaining fingers on the right. Three times two is six. Six is then added to fifty to obtain the final answer: fifty-six. The method never fails.

Morning meteors

Here are two apparently unrelated facts:

1. When the earth is experiencing a meteoric shower, more meteors (commonly called "shooting stars") can be observed from midnight to sunrise than from sunset to midnight.

2. When you run through the rain your face gets wetter than the back of your head.

Can you explain the scientific connection between these? (See Answers.)

— GEORGE GROTH

Answers

DOUBLE DATE: Smith is 29 years old (born in 1929) and his grandmother is 79 (born in 1879).

DOUBLE IMAGE: 37 degrees. Although the sides of the angle will double in length, the size of the angle itself will be unaffected by the magnification.

MORNING METEORS: Think of the earth as a gigantic head and the meteors as drops of rain. As the earth plunges through the meteoric swarm, its "face" (the side facing the direction of motion) will naturally get "wetter" (catch more meteors) than its opposite side. From sunset to midnight you are on the "back" of the earth, but after midnight you are on the side that is speeding into the meteoric rain.

Stranger than fiction **By Murray Morgan**

The case of the silent howlers

With the discovery that yellow fever could be transmitted through a jungle vector, scientists were again plunged into extensive research. Part 2

The story to date

The long campaign against yellow fever was drawing to what seemed to be a successful conclusion, for the disease no longer swept unchecked through cities and towns. Scientists had isolated one kind of mosquito, Aedes aegypti, *a town-breeding vector, and proved it the carrier. They had developed a vaccine as protection against yellow fever. Complete protection, through exterminating* Aedes aegypti, *seemingly lay within their grasp. Then yellow fever broke out in Vale de Canaan, Brazil, where there were no* aegypti.

With this development, the cornerstone was pushed out of the theory that ridding the world of *Aedes aegypti* would break the chain of transmission from man to mosquito to man and thereby end yellow fever. Now there were additional factors to consider.

Dr. Fred L. Soper and other researchers set out to explore this new phenomenon. They studied the mosquito population to find which ones might be transmitting the disease in the absence of *aegypti*. While none were caught carrying virus in the field, several types were shown capable of infecting laboratory animals. Tests of blood taken from monkeys captured in the jungle showed the presence of antibodies against yellow fever.

At the time that Soper was working in Vale de Canaan, the Rockefeller Foundation sent another expedition to Muzo, Colombia, an area that had long puzzled yellow-fever experts. There are emerald mines in the jungle near Muzo. The stones are found near the surface, and the mines are worked by sending men into the jungle to clear the vegetation and strip back the surface dirt. These men often become sick. During an epidemic in 1907, a Colombian doctor, Roberto Franco, wrote a report saying that the men were suffering from yellow fever, but of a strange sort that was transmitted by mosquitoes other than *aegypti*. The experts of Dr. Franco's time disagreed, but workers continued to sicken and sometimes die.

So it was that an international team led by a 32-year-old scientist named John Austin Kerr came to the area and sweated out a miserable summer gathering blood from the emerald-diggers. Their findings: yellow fever was definitely being transmitted at Muzo in the absence of *Aedes aegypti*. Dr. Franco had been correct.

Gradually, a new theory about yellow fever was taking shape. In 1935, Dr. Soper suggested that there were natural hosts to the disease other than man, that they lived in the jungle and received the disease from some vector other than *Aedes aegypti*. To differentiate this disease from the classic form of yellow fever, Soper coined the term "jungle yellow fever."

Jungle yellow fever was the same disease as urban yellow fever. But it was not being transmitted in the same way. How was it being transmitted? That was the question. And scientists had to find the answer before they could bring the disease under control.

The story of yellow-fever research during the next few years is primarily the story of scientists who went into the jungle and brought back the report of how jungle yellow fever maintains itself, what animals harbor it, what insects transmit it, and how man occasionally blunders into the path of the disease.

One of these jungle scientists was an obscure young Colombian doctor, Jorge Boshell Manrique. Dr. Boshell symbolizes the small band of dedicated jungle scientists who solved the jungle-fever mystery.

He began as a horse-and-buggy doctor in Villavicencio, a small town across the mountains from Bogotá, Colombia. "It was quite a place, Villavicencio," he told me. "It was a cow town. It was a country ruled by the gun." It was also a land of opportunity for a doctor. When an epidemic broke out in a village near Villavicencio, the governor asked Dr. Boshell to go.

"So," Boshell said, "I got my little black bag and my horse and I forded the river and rode over there. I found malaria in the town. There was always malaria in that town. But I soon became convinced there was something else, and I thought it was yellow fever. But the dogma was that you couldn't have yellow fever without *Aedes aegypti*, and there was certainly no *Aedes aegypti* around there — plenty of other mosquitoes, but no *aegypti*.

"This was in 1934. Soper had done his preliminary work on jungle yellow fever, but I was behind on my reading. Journals reached me as much as two years late, and I hadn't read Soper. I merely had the facts I had collected and I had the dogma which said there couldn't be yellow fever without *aegypti*. All my life I have distrusted dogma. I decided to perform autopsies to get specimens of the livers of some of the people who had died."

Boshell sent his liver specimens to Bogotá. They were forwarded to Rockefeller Foundation laboratories in New York and Rio de Janeiro, where his diagnosis of yellow fever was confirmed. The Rockefeller people sent him back collecting equipment and asked him to bleed the convalescents.

"So I rode back across the river — believe me, people in that place hated to see me coming — and I bled them, over their objections, and sent the serum. There were antibodies for yellow fever in it, of course. The Rockefeller people came on the double. They suggested I should devote my full time to yellow-fever work. That is how I

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happened to give up the private practice of medicine."

Boshell became a full-time research worker. He and John Austin Kerr, among others, went into the forest for months at a time to capture and bleed an extraordinary assortment of monkeys, marsupials, and rodents.

Their information, when added to that from other South American laboratories, indicated that the spider monkeys, the howlers, and the night monkeys were particularly susceptible to yellow-fever virus. But how did they catch it?

The scientists had a number of clues. They had noticed that jungle yellow fever most frequently struck robust men whose work had some relation to the forest, such as woodcutters and road-builders. They reasoned that the insect vector was probably one that stayed near the forest. This seemed even more probable since it was rare for the disease to spread within a family, which indicated that the transmitting insect did not frequent houses. The infection seemed to be acquired during the day rather than at night. Everything indicated that the jungle-yellow-fever cycle involved monkeys and mosquitoes. But which mosquitoes?

The leading candidate was a hard-biting species called *Haemagogus spegazzinii.* Rockefeller researchers had found some *spegazzinii* in Brazil which were infected with the virus. But in the laboratory *spegazzinii* was something of a disappointment — hard to breed in captivity, hard to keep alive, and only intermittently successful in passing on yellow fever to lab animals. Furthermore, entomologists in the jungle found so few *spegazzinii* that they doubted the species could play a major role in infecting the monkeys.

Then, in 1940, an outbreak of yellow fever was reported near the headwaters of the Rio Ocoa in Colombia. Boshell and an associate, Dr. J. H. Bugher, had mobilized a field laboratory to study just such outbreaks. They set up camp near the river.

One morning Boshell went into the jungle with some woodcutters. He wanted to collect mosquitoes. He jumped up and down to work up a sweat, then took off his shirt and sat on a log, waiting for mosquitoes to land on him. But they weren't biting. Boshell put on his shirt and was about to leave when one of the woodcutters shouted that a tree was about to fall. Boshell stood back to watch the slow, stiff, tilt of the great tree, then its rushing fall through the lesser growth and its final crash. Sunlight streamed through the hole in the jungle canopy, and from the upper branches of the fallen tree rose a blue cloud of mosquitoes which swarmed around the sweaty woodcutters. Boshell caught some of them: *spegazzinii! spegazzinii* in great numbers.

So it was learned that the *spegazzinii,* relatively rare on the floor of the jungle, exist in swarms in the leafy canopies of the forest. There, too, the monkeys live.

From this observation, and many that followed, came the last of the materials needed to build a solid theory about the epidemiology of jungle yellow fever. It is primarily a disease of monkeys living in the jungle canopy. They are infected by the bites of several species of mosquitoes, with *Haemagogus spegazzinii* one of the most important offenders. The cycle is maintained — monkey to mosquito and back to monkey — but men going into the jungle may get involved, particularly if their work disturbs the jungle canopy. If the man bitten by an infected mosquito then returns to a city where there are *Aedes aegypti,* he may start anew the urban cycle of man to mosquito to man.

Urban yellow fever moves from city to city with the movement of man. Jungle yellow fever, it is believed, spreads not so much through the migration of the monkey host — for monkeys tend to stay near one spot — but by the movement of mosquitoes. The vectors of yellow fever, it has been shown by Ottis R. Causey, a researcher from South Carolina, can fly considerable distances; but, judging by the speed with which the fever spreads through the jungle, it is now thought that the infected mosquitoes, living high in the forest canopy, are sometimes caught in updrafts, blown well aloft, and then carried for miles by the wind to be dropped in another part of the forest. This, if correct, would explain the patchy pattern of infection.

With the jungle-fever mystery solved, the Rockefeller Foundation in 1942 closed its field work in Colombia. Boshell spent the next few years organizing the National Institute of Health in Bogotá and the Rockefeller Public Health School. But he missed the forest and field. When yellow fever crossed the Panama Canal in 1949-50

and Dr. Soper asked him to help plot its northward course, it was back to the jungle for Boshell.

In Panama City, only a block from the Pacific, stands a pleasant, old-fashioned mansion, which some years ago was turned into the headquarters and workrooms of the Gorgas Memorial Laboratory. It is one of the best research organizations in the world, manned by some of the most irrepressible, most imaginative scientists who ever made tea in a beaker.

When yellow fever crossed the canal, Dr. Harold Trapido, one of the entomologists, set out to learn more about the circumstances of the mosquitoes' giant leap. Blood immunization tests indicated that the disease had on other occasions approached the canal, once coming within thirty miles, without getting across. Trapido wanted to find out what had been different this time.

After four years of studying the mosquito population of the forest canopy in the isthmus, then poring over weather records, Trapido suggested a complicated but convincing hypothesis. Greatly simplified, it is:

There are cycles in the movement of virus, with periods of great activity following periods of lull. There are also cycles in the number of *spegazzinii* in the forest. In previous years, the peak period of movement of virus had not happened to coincide with the peak period for mosquitoes. In 1950, the rainfall was heavy enough to stimulate an increase in mosquito population. There was abundant virus, there were many mosquitoes, and some of them flew or were blown across the canal, and survived.

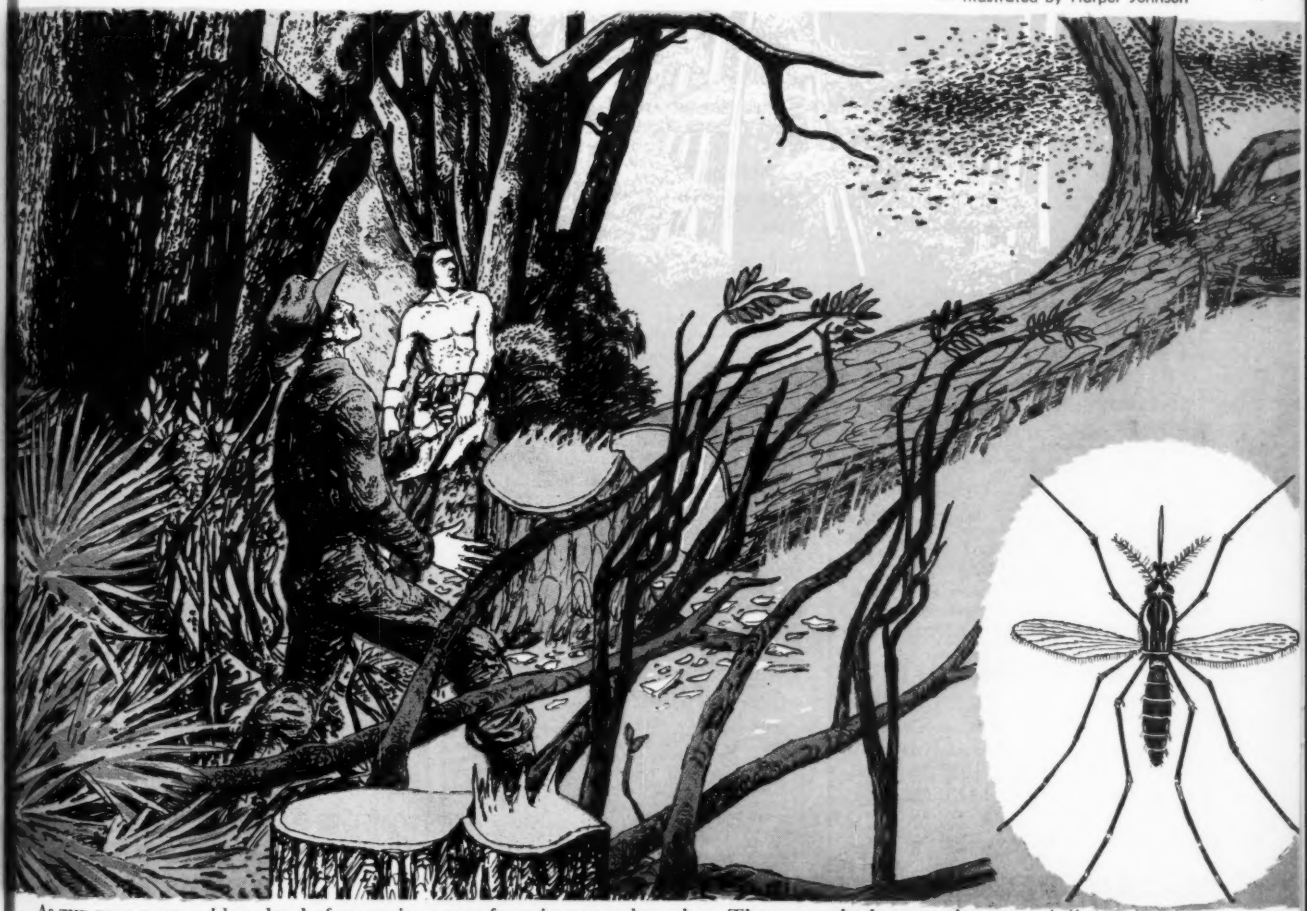
Meanwhile, another Gorgas entomologist, Dr. Pedro Galindo, was working on a still more complicated aspect of the problem. He was trying to learn how the virus survives in the forest during the dry season.

Spegazzinii lives in tree holes near pools of water. It lays its eggs above the water line. They withstand dessication until the rains come, at which time the water rises to the level of the eggs, and they float free and hatch. During the dry season the adults, whose life span is from four to six weeks, disappear from the forest. Now, since the adults die off and the offspring do not inherit the virus, and since in monkeys yellow fever lasts only a few days before the animal dies or develops antibodies, the question arises as to where the pool of virus is maintained. It is possible that there is some undiscovered host, some rodent or marsupial. It is also possible the virus lingers in a long-lived species of mosquito.

Galindo learned that one other mosquito, a big, bright-colored creature with yellow markings, was always present in Panama where there was yellow fever — but present in such small numbers that entomologists felt it was not likely to be a vector. Galindo decided to colonize this species, *sabethes*, and study it.

"We had a two-year battle on that, *sabethes* and me," Dr. Galindo has

— Illustrated by Harper Johnson



AS THE TREE FELL, a blue cloud of mosquitoes rose from its upper branches. They were the long-sought *spegazzinii* (*see inset*).

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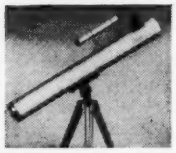

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said. "No one had ever succeeded in colonizing *sabethes*. She simply refused to lay eggs."

After repeated failures to get his females to breed, Pedro Galindo took to the forest to study them more carefully in nature. He found they laid their eggs in water that had gathered in holes in trees. The water had to last through the dry season, so *sabethes* invariably deposited her eggs in holes that had small openings at the top, then widened out toward the bottom — flask-like holes that inhibited evaporation.

He decided to copy such a breeding place for his colony. Having found a bamboo stump that had ripened well, he closed the top with a piece of heavy paper, bored a small hole at the side, poured in water, and set the stump in the breeding cage. The mosquitoes circled around it buzzing briskly. Then there came for Dr. Galindo a moment of pure triumph: a female headed for the hole and disappeared inside.

From the resulting domestic colony, Dr. Galindo learned that under laboratory conditions *sabethes* may transmit yellow fever from monkey to monkey, and that she has a life span of five months or more. He showed me several venerable mosquitoes buzzing in a large wire cage; they had survived seven months and were still considered virulent.

"From what we have learned," he said, "we consider it possible that *sabethes* is a poor but durable vector. She may survive from one rainy season to the next, holding in her system the virus. It may be she who reinfects the monkeys — or, for that matter, other hosts — at the start of the rainy season. As a result, they have the disease ready in their veins to pass on to the swarms of *spegazzinii* that arise from the holes after the rain reaches the eggs.

"If this should prove to be the pattern," he said, looking thoughtfully at the cage of yellow-striped *sabethes*, "we see here what may be the weak link in the chain of survival of the virus in the jungle. It is possible, just possible, that any appreciable lowering in the number, or the effectiveness, of *sabethes* might break the chain of transmission. So we must learn more about these mosquitoes."

[*To be concluded Dec. 9*]

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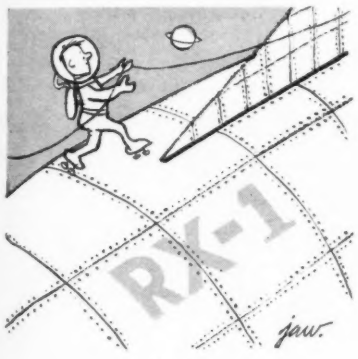
Kenneth Campbell of Cloverport, Kentucky, writes:

Will it be possible for man to walk around on the outside of a spaceship in outer space?

Probably it will. The man, of course, will have to wear a special air-conditioned, pressurized space suit. And since he'll be weightless in space, he'll have to be attached to the ship in some way — perhaps with magnetized boots, if the ship's hull lends itself to such use. Otherwise, the slightest push would send him drifting through space. Though the spaceship will be traveling at a terrific speed, there will be no danger of his being "blown off." For there are practically no air particles in the near-vacuum of space.



Eilene Sikes of Westfield, Massachusetts, writes:

Is there a temperature at which an element would freeze so that all movement of molecules would stop? If so, would the element fall apart?

All molecular movement would stop only at a temperature of absolute zero: minus 459.6°F. At such a temperature, however, the element would not fall apart. It is motion, rather than lack of motion, that drives molecules apart.

Peter Gordon of Penticton, British Columbia, writes:

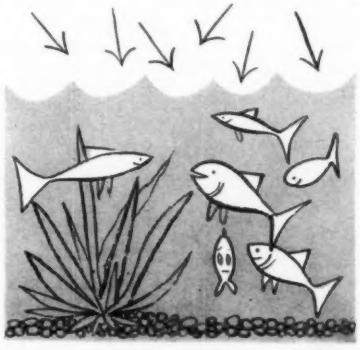
Why can't scientists achieve absolute zero?

To achieve absolute zero, scientists would have to remove all heat. (By definition, absolute zero is the complete absence of heat.) One of the methods they use in approaching this goal is to "dilute" the heat. So far, they have not managed to "get rid of" all of it. To explain their problem in detail would take pages, but a good idea of it can be obtained from this rough analogy: Suppose you have a quart container half full of ink and half full of water — and that the ink is a continuous substance. You want to get rid of the ink by dilution. You pour out half the contents of the container and replace it with a pint of water. You repeat this process over and over again. The amount of ink in the container grows steadily less. But even if you use all the water in the world you will never succeed in getting completely rid of every iota of ink.

Susan Casper of Solvay (N.Y.) High School writes:

How do lakes purify themselves?

Self-purification — a complicated process — is the same in all bodies of water. In simplified terms, it works like this: Suppose that solid waste materials enter a lake. Bacteria in the water and in the waste matter itself gradually break down the wastes into products that later become food for fish. In the process, the bacteria use up dissolved oxygen in the water. The supply is replenished by oxygen taken from the air and by oxygen produced by water plants. Using this oxygen, the bacteria continue their job.



Self-purification works faster where there are ripples and waves, for these create greater surface areas through which the oxygen can be absorbed. Motionless waters require more time. If the volume of pollution is so great that the bacteria use oxygen more rapidly than it can be replaced, self-purification is slowed. The water becomes greasy and foul-smelling. Fish and other marine life, which require oxygen, disappear.

Robert Newmark of Brooklyn, New York, writes:

What are the highest and lowest temperatures ever recorded on earth?

A searing 136.4° Fahrenheit was recorded in September, 1922, in northwestern Libya. It is generally considered the highest official temperature. Temperatures of 158° and "nearly 170°F." have been reported in the Danakil Desert in Ethiopia. But these cannot be accepted as official, since details are lacking on the accuracy and exposure of the thermometers used.

The low-temperature record was set in August at the Russian antarctic station Sovietskaya. There, minus 124.1°F. was recorded.

Questions from readers will be answered here, as space permits. Send to: Question Box, Science World, 575 Madison Avenue, New York 22, N.Y.

There's a Metal Problem in your future that Inco can help you solve

In the meantime, see if you can tell which nickel-containing alloy proved to be the answer to these problems.

Number the picture captions!

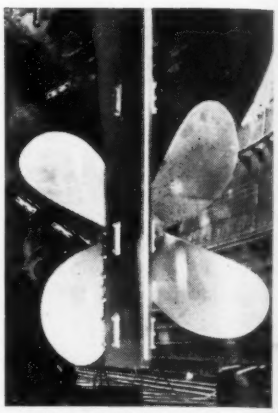
1. Nickel cast iron
2. Chromium-nickel stainless steel
3. 4340 constructional alloy steel
4. Ductile Ni-Resist*
5. Cupro-nickel
6. Nickel-aluminum bronze
7. Ni-Resist nickel cast iron

*Registered trademark

See answers below

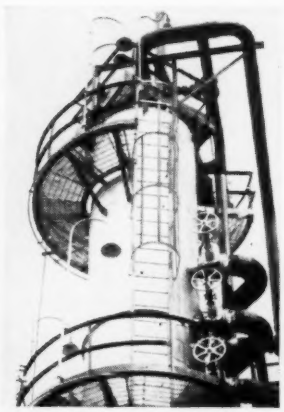
☐ **Piston ring carrier insert**—Needed: wear resistance, thermal expansion to match aluminum. Which alloy?

☐ **Grader drive axle**—Needed: toughness, impact resistance, greatest strength, with least weight. Which alloy?

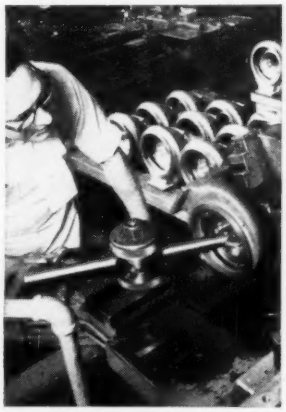


☐ **Ship's propeller** — Needed: light weight, high resistance to erosion, sea water corrosion. Which alloy?

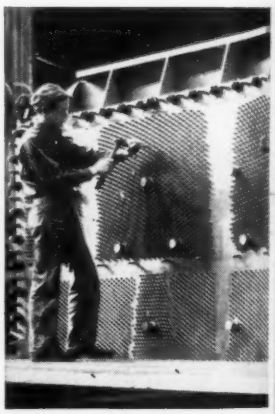
☐ **Yankee dryer roll** — Needed: high strength, uniform structure in cross sections of heavy castings. Which alloy?



☐ **Catalytic polymerization tower** — Needed: resistance to phosphoric acid at 375°F, 500 psi. Which alloy?



☐ **Turbocharger housing** — Needed: resistance to thermal shock, heat, corrosion at 1500°F. Which alloy?



☐ **High pressure marine condenser**—Needed: heat transfer, stress, corrosion resistance. Which alloy?

You may have to take this kind of quiz *again*. You may be designing a machine which requires a metal that resists corrosion . . . or wear . . . or high temperatures. Or one that meets some destructive *combination* of conditions.

When you start to design equipment, you will have to select the proper material to meet given service conditions. Over the years, Inco Development and Research has successfully solved many metal problems, and has compiled a wealth of information to help you.

For more on special problems solved with nickel-containing alloys, send for "Standard Alloys for Special Problems." Write The International Nickel Company, Inc., Dept. 190G, New York 5, N. Y.

The International Nickel Company, Inc.
New York 5, N. Y.

answers

- Piston ring carrier insert.....7 Ni-Resist
- Grader drive axle.....3 4340 constructional alloy steel
- Ship's propeller..6 Nickel-aluminum bronze
- Yankee dryer roll.....1 Nickel cast iron
- Catalytic polymerization tower .....2 Cr-Ni Stainless
- Turbocharger housing..4 Ductile Ni-Resist
- High pressure marine condenser.....5 Cupro-nickel

Inco Nickel
makes metals perform better, longer

Science teacher's question box

Why is it that American automobile engines seem to have such large horsepower ratings for their size? — T. B., New York, N.Y.

The horsepower of American cars is determined by testing procedures set up by the Society of Automotive Engineers. No formula, as such, is used. Under certain specified conditions, the horsepower is measured by means of an electric dynamometer, which is simply an electric generator driven by the engine under test.

The engine being tested is run as a "pure" engine. None of its power is used to drive fuel pumps, oil pumps, generator, etc. In other words, no horsepower is removed from the engine to drive any accessories. The engine is run at a maximum rpm. (as high as 4,000 rpm.) for as long as 100 hours.

The result is horsepower under perfect conditions, with no losses other than friction and heat. This is the maximum horsepower that the engine is capable of delivering. The engine is very rarely, if ever, required to operate at such a horsepower. Even when a car is driven at 60 mph., the horsepower developed is only a fraction of that developed on the test block.

There are many ways of computing the theoretical horsepower of piston engines. A common textbook formula is:

$$\text{h.p.} = \frac{\text{plan}}{33{,}000 \text{ ft. lbs./sec.}}$$

Here, p is pressure, l is length of stroke, a is area of piston head, and n is number of revolutions. In modern engineering practice, however, horsepower is determined by test rather than by formula.

When you read articles in newspapers and magazines concerning the large number of new atomic particles — there seem to be well over twenty now — you wonder how long these particles exist. Are they present all the time? — C. deB., Brighton, Mass.

Almost all these particles lead a short and fast life. In many cases they seem to exist only for intervals shorter than a millionth of a second. They are only produced during a time of great nuclear change brought on by cosmic rays or in powerful accelerators or cyclotrons. Some are very difficult to detect and record. Very often, these particles are the result of energy being converted to mass or the reverse. Probably many more of these strange beasts will be discovered.

Can you suggest a simple way to make a seconds pendulum that will produce an electric contact to operate a bell or a relay so that the entire class can listen to the time intervals? — S. A., Atlanta, Ga.

Attach an ordinary metal pendulum bob to thin copper wire (No. 24 to 28) that has an over-all length of a meter. Allow a short length of wire to extend below the metal bob. Support the copper wire from a metal rod in a ringstand and clamp. Under the bob place a shallow dish containing a pool of mercury. The wire under the bob should make contact with the mercury. Allow another wire to dip into the mercury as a contact. Then connect a 3-volt electric bell in series with two dry cells, the wire from the pendulum, and the wire dipping into the mercury pool. Thus, every time the pendulum passes the lowest point in the arc of its swing, a circuit is closed and the bell rings. In this case, it will be every second. To design pendulums for time-periods other than one second, solve the following equation for l (l equals length in cm.; g equals 980 cm./sec./sec.; and p equals period in seconds or parts of a second):

$$p = 2\pi \sqrt{l/g} \text{ or } l = g \times (p/2\pi)^2$$

Questions from teachers will be answered here, as space permits. Send questions to: Science Teacher's Question Box, Science Teacher's World, 575 Madison Avenue, New York 22, N.Y. We regret that questions cannot be answered by mail.

INCO suggests

The following student activities are based on the advertisement appearing on page 28.

1. Why is nickel so important an element in alloys used to make heavy-duty mechanical equipment?
2. How is nickel used in industrial chemical equipment?
3. Why is nickel useful in a high-pressure marine condenser?
4. Why is nickel useful in very large iron castings?
5. Review in a chemistry text how nickel is refined from its ore.
6. List the properties that make nickel alloys so useful.
7. Explain how nickel behaves in the presence of some strong acids.

(Advertisement)

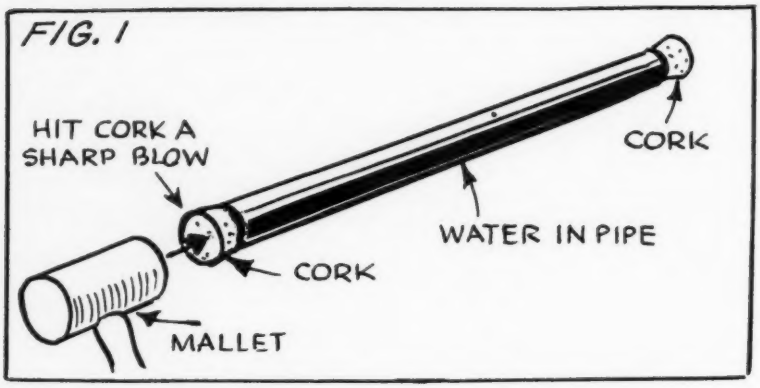
TV program on cosmic rays

With all the data on cosmic rays coming in from satellites, airplanes, and high-flying balloons, teachers may be interested to know that the Bell System Science Series will rerun its color television program, "The Strange Case of the Cosmic Rays."

First telecast last year, the hour-long program will be presented over NBC-TV on Sunday, November 23. (See your local TV listings for the time.)

The program covers the work of scientists during the past fifty years in tracking down and identifying this radiation from space. A cloud chamber, similar to those used to study cosmic rays, will be put together during the program. The working of the chamber will be explained, and tips will be given on how to make a small, simple one at home. The program will also show how the scientific method operates and how studies in one field of science can benefit those in other fields.

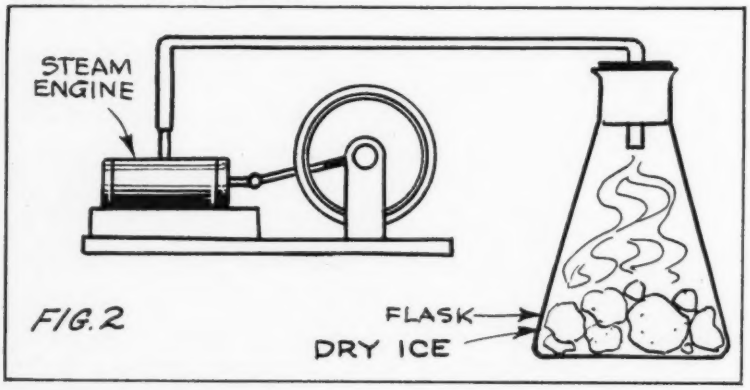
How to do it



Demonstrating Pascal's law

Pascal's law can be simply demonstrated in a few minutes with a short length of pipe, two corks, water, and a mallet or hammer. First, cork one end of the pipe and fill it with water. Then cork the opposite end. Now tap one cork sharply with the mallet or hammer (Fig. 1). The cork at the other end will shoot out. Do this over a sink, since water will also come out. If the tube is pointed upward at a 45-degree angle, only a few drops of water will follow the cork.

— Drawings courtesy of Popular Science



Running a model steam engine on carbon dioxide

In demonstrating the operation of the reciprocating steam engine, it's frequently a problem to have steam available at a moment's notice.

Since such an engine ordinarily obtains its mechanical energy from the expansion of steam (a gas), it is possible to substitute for the steam expanding carbon dioxide obtained from dry ice.

Place roughly the equivalent of two one-inch cubes of dry ice in a flask. (*Warning:* handle dry ice with gloves.) Close the flask with a one-hole stopper. With a rubber tube, connect the steam intake of the model steam engine to the hole in the stopper. (If you do not have a model steam engine, you may be able to borrow one from a student.)

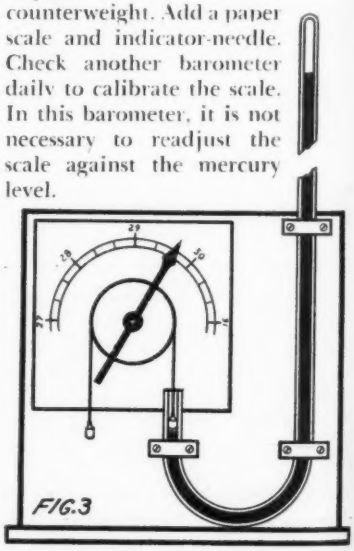
Now remove the stopper, add hot water to the flask, and replace the stopper. The gaseous carbon dioxide will evolve rapidly from the dry ice (Fig. 2). When it reaches the steam engine's cylinder, the carbon dioxide will expand, causing the engine to operate. Additional hot water and dry ice may be added to the flask as needed. A model steam turbine can also be operated in this way.

Making a direct-reading mercury barometer

The direct-reading mercury barometer can be easily constructed, as in Fig. 3. The vertical part of the closed-end barometer tube is glass tubing that has a ¼-inch internal diameter. The U section below the two clamps is rubber tubing. The part of the barometer tube above the left clamp is a short piece of glass tubing of the same internal diameter as the other glass tubing. A wooden backboard about 12 inches square is attached by angle irons to a 12-inch-square baseboard. The angle irons are not visible in the drawing. The clamps are strips of aluminum, with felt or rubber underneath to protect the glass tubing. They are held in place by wood screws.

When the apparatus has been assembled, fill the tubing with mercury. Stop when the mercury is 8 inches from the top. Next, fasten the tubing in place on the backboard. The level at the closed top of the long tube will drop until the column is approximately 76 cm. high, depending on altitude and atmospheric pressure.

Now fasten a string to an iron rod ¾-inch long and ¼-inch in diameter. Lower the rod into the open end of the tube until it floats on the mercury. Place a lightweight pully on the backboard and bring the string over the pulley. On the other end of the string, attach a duplicate iron rod as a counterweight. Add a paper scale and indicator-needle. Check another barometer daily to calibrate the scale. In this barometer, it is not necessary to readjust the scale against the mercury level.



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PLEASE PRINT

SCHAAR AND COMPANY, besides providing a complete line of laboratory apparatus and instruments, reminds science educators of its Repair Service Department. Serving educational and industrial laboratories for the past 50 years, Schaar's repair facilities include service on balances of all types, *p*H meters, and electronic instruments. As an added service, balances lent without charge while yours are being repaired. *(For more information about Schaar's repair service, check No. 1125A.)*

CAMBOSCO SCIENTIFIC COMPANY solves one of the problems of school laboratories that lack gas facilities with its new low-cost and highly efficient Cam-Lab Burner. The Cam-Lab Burner, using liquefied petroleum, gives a true Bunsen flame with well defined oxidizing and reducing zones. The flame is controllable with a needle valve, and a wing top adapts the new type burner for glass tubing manipulation. At least eight hours of continuous operation is provided by a single fueling. *(Check No. 1125B for details on Cam-Lab Burner.)*

F. W. DWYER MANUFACTURING COMPANY now makes it possible for you to use your classroom barometer with the low-cost Dwyer windspeed indicator to form the basis for accurate weather study and predictions. The indicator registers velocity by a liquid-filled tube in both miles per hour and Beaufort Scales Designations, reading just like a thermometer. Mounting can be made on any outside, obstruction-free elevation. Fifty feet of Vinyl plastic tubing connects outer unit to gauge. *(Check No. 1125C for information about the windspeed indicator.)*

'Tools' question box

Any questions on teaching tools? Send them to: "Tools" Question Box, Science Teacher's World, 575 Madison Avenue, New York 22, N.Y.

L. J. M., Ames, Iowa: "Has anyone ever devised a simple visual demonstration of Le Chatelier's Principle?"

Answer: Probably many people have. The most recent one that comes to mind is Tucker's approach: "Apparatus for Illustrating Le Chatelier's Principle," *Journal of Chemical Education*, Vol. XXXV, No. 8, August 1958, page 411.

Shop talk

A mechanical device for teaching theoretical concepts

Many a chemistry teacher has pondered the problem of how to put across the theoretical concepts of chemistry that students find hard to grasp. An unusual approach to this problem has been worked out by Max C. Epstein of New Utrecht High School in Brooklyn, New York. He uses a mechanical device to demonstrate the following theoretical concepts: atomic structure, isotopes, differences between an atom and an ion, formation of a polar molecule, valency (electro- and co-valence), oxidation and reduction, the fate of oxidizing and reducing agents, electron equations, the balancing of equations, and electrolysis.

The device is shown in Fig. 1 on page 8-T. It consists, essentially, of a large plywood baseboard, three plywood disks that represent atoms, and checkers with minus signs painted on them to represent electrons.

Construction

To make the calcium atom, paint only three of its four electron orbits on a plywood disk. Glue the appropriate number of checker-electrons on each orbit. Paint in the nucleus, using a different color for each item. Then glue the disk to the baseboard. Paint the orbit for the two outermost electrons on the baseboard outside the disk.

To make the chlorine atoms, paint in the orbits and nucleus. Glue on the checker-electrons as indicated. Using a brace and bit, cut out the outline of the missing electron in the outermost orbit of each disk-atom.

Cut two channels one-half inch wide through the baseboard, from front side to back side. Each channel should extend from the position of one outermost electron of the calcium atom to the middle of the position of one chlorine atom. If no jig saw is available, use a drill to make closely spaced quarter-inch holes. Then cut away the remaining wood to form the channels.

Now cut four wooden blocks, each measuring 1 x 1 x 2 inches. Put screws through these blocks. Place the blocks on the back side of the baseboard so that two screws extend through each of the two channels. Screw on the two outermost calcium electrons and the two chlorine atoms. These will now be free to slide toward each other

when moved by the blocks from behind the baseboard. (See Fig. 2.)

When legends and equations are painted in, says Mr. Epstein, the device is ready to be used for the following demonstrations.

To show atomic structure: Point out how the number of neutrons is obtained by subtracting the atomic number from the atomic weight. Refer to the various orbits, shells, and orbital electrons.

To show isotopes: Refer to the other two isotopes of chlorine indicated on the baseboard. Point out that the atomic numbers and orbital electrons are the same for all isotopes of an element, but that the atomic weights and the number of neutrons vary.

To show differences between an atom and an ion: Refer to the zero valences of the calcium atom and the chlorine atom. Then refer to the ions in the molecule on the right side of the equation. Show that valency depends upon the charge of the ion, which is conditioned by the electrons gained or lost in the transfer.

To show formation of the polar molecule: Transfer the two movable electrons from the calcium atom to the chlorine atoms. Now, with their newly acquired electrons from the calcium atom, shift the two saturated chlorine atoms close up to the calcium atom (now left without its two electrons). Point out the crisscross method of writing the formula of a compound without having to draw the atoms or to shift their electrons.

To show valency: Refer to the gain and loss of electrons by each atom, as valence becomes plus two for Ca and minus one for Cl. This transfer of electrons causes the formation of a polar or ionic compound whose valence is called electrovalence. Point out that when electrons are shared, a non-polar compound is formed whose valence is called covalence.

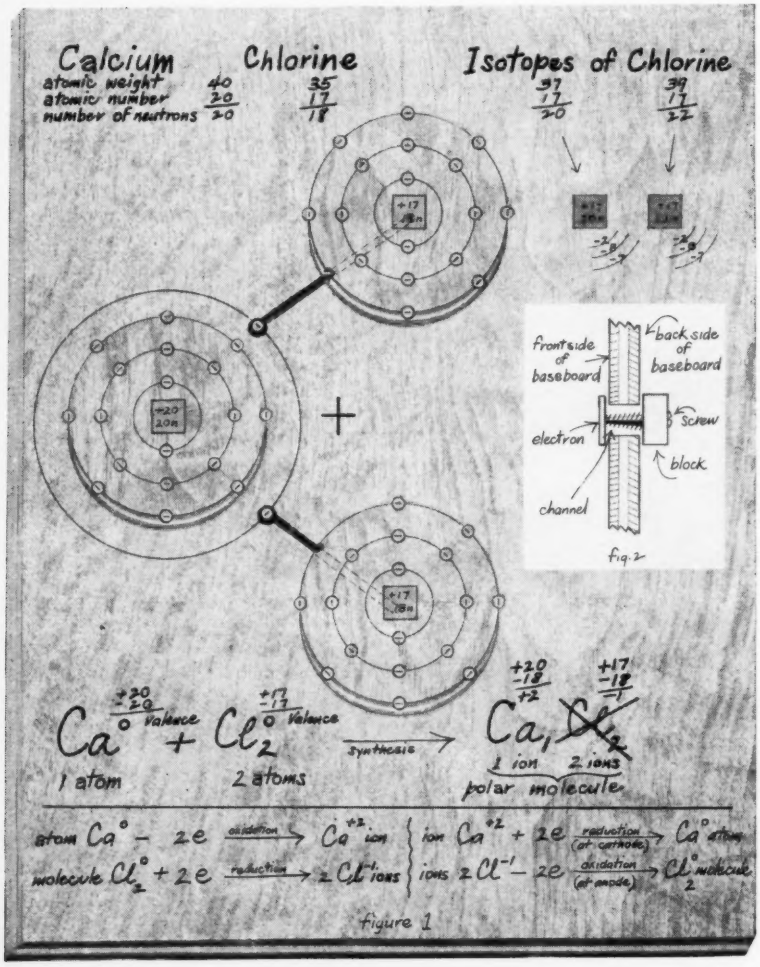
To show oxidation and reduction: Use the electron equations on the baseboard. By shifting the orbital electrons back and forth, show how the definition for oxidation and reduction hold true, since there is an increase and decrease in the valences and a gain and loss of electrons.

To show the fate of oxidizing and reducing agents: Again use the electron equations, pointing out that in the process oxidizing agents are reduced while reducing agents are oxidized. This proves that oxidation and reduction occur simultaneously.

To show electronic equations: Refer to the equations on the baseboard and highlight their use and importance.

To show how equations are balanced: Teach the class to count the number of atoms on the right side of the equation and check this number with the number on the left side. Point out the significance of atoms and molecules in the equation.

To show the concept of electrolysis: Focus attention on the closely knit $CaCl_2$ ion molecule. Then separate the Ca ion from the two Cl ions. Next transfer the acquired electron from each Cl ion back to the Ca ion. Point out how the atoms of Ca and Cl are formed at the respective electrodes when direct current is passed through them during electrolysis.

With the aid of this mechanical model, says Mr. Epstein, a teacher can point out many other significant points in the theory of electrolytic dissociation and the electron theory. "Since seeing is believing," he adds, "why not use it for more effective teaching?"

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